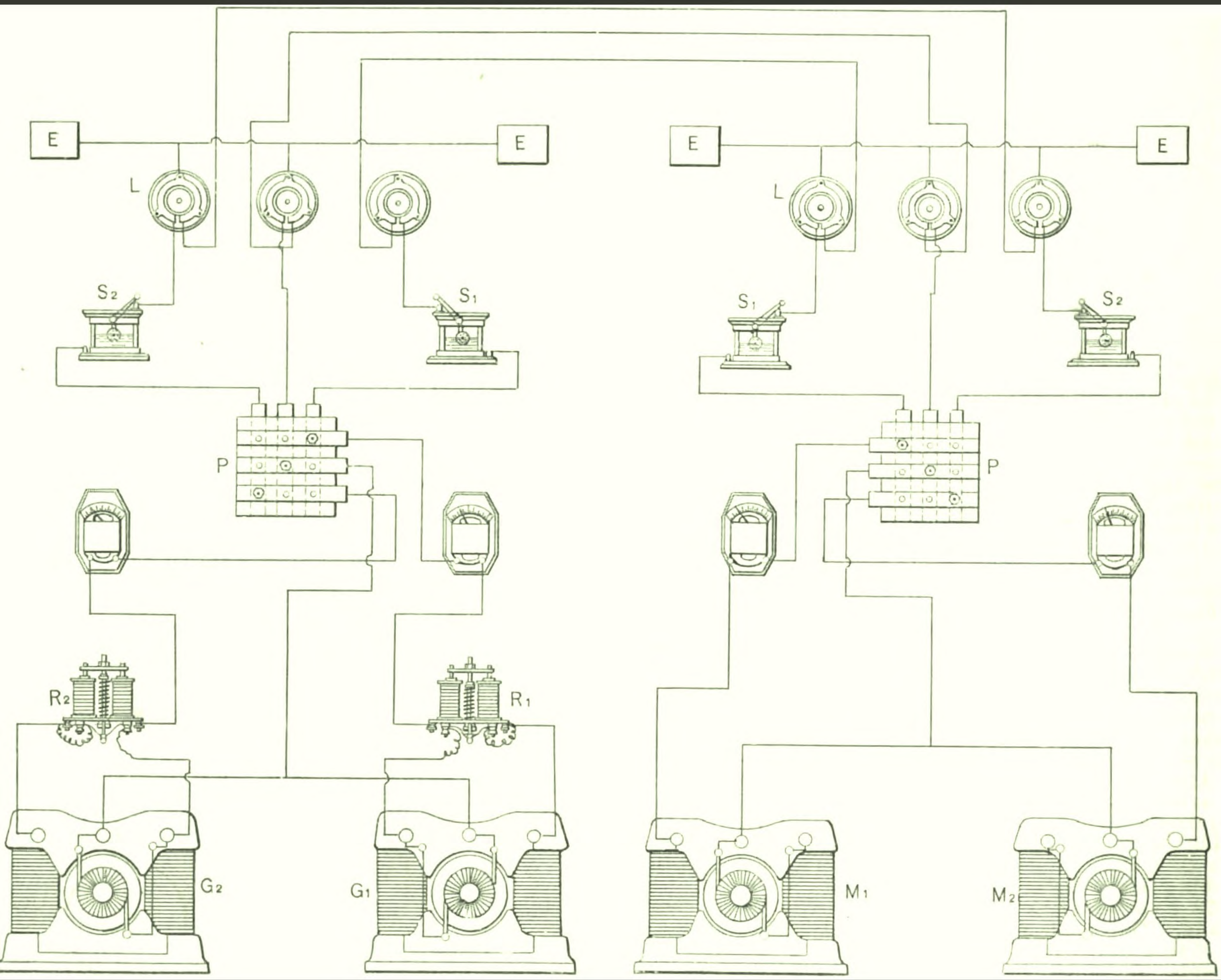

Electrical engineer


VASSOS

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THE

ELECTRICAL ENGINEER.

A Monthly Review of Theoretical and Applied Science.

VOLUME VII.—1888.

(January to December.)

NEW YORK:

ELECTRICAL ENGINEER.

11 Wall Street.

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THE ELECTRICAL ENGINEER.

THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS, JR.

PUBLISHED MONTHLY BY

THE ELECTRICAL PUBLISHING CO.,

115 Nassau Street, New York city.

European Agent, F. H. WEBB, 4, The Sanctuary, Westminster, London, S.W., Eng.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
One Copy, Four Months,		1.00
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies,		.30

[*Entered at the Post Office at New York, N. Y., as second class mail matter.*]

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NEW YORK, JANUARY, 1888.

We are pleased to renew our announcement of last year that by arrangement with the ELECTRICAL WORLD, *we are able to offer that excellent weekly journal in conjunction with* THE ELECTRICAL ENGINEER, *for one year to new subscribers for* $5.00. *To those of our present subscribers who desire it we will supply the* ELECTRICAL WORLD *one year for* $2.50

THE WRONG WAY AND THE RIGHT WAY.

A WELL-KNOWN electrician of our acquaintance had occasion a short time since to consult a manufacturer of locomotives, whose street-railway motors have attained a national reputation for economy and general efficiency, with reference to the construction of an electric motor. The manufacturer at once exclaimed that it was useless for him to estimate on electric machinery,as he had found by experience that electrical people would not pay for the quality of workmanship that was required for proper locomotive running gear. What they wanted, he said, was a cheaper class of work, such, for example, as that used in a rather poor grade of agricultural implements.

This remark might well furnish a text for a very instructive sermon. If a locomotive is to haul a certain load over a given track, it is certainly very poor economy to use less perfect running gear for an electric than for a steam motor. Yet many electric motors which we have seen are eloquent witnesses to the truth of the remarks of the locomotive builder. And as if this were not enough, we have noted a certain disposition on the part of some electric-railway people to undertake what may be called feats of sensational engineering, such as running over imperfect tracks, and up and down impracticable gradients, and the like. There is no reason whatever to suppose that an electrically driven locomotive can run with safety where a steam driven one cannot, yet it is quite apparent that many people who ought to know better are being carried away with the delusion that any railway problem that presents peculiar difficulty can be solved at once by the application of electricity, just as we heard it gravely argued, during the prevalence of the narrow-gauge craze some years ago, that a locomotive of three feet gauge could ascend a steeper incline, other things being equal, than one of 4 feet 8½ inches gauge. We hear, for instance, of one line on which an attempt is to be made to work grades of over 700 feet per mile with electric locomotives, for passenger service. Unless special precautions are taken, as, for example, on the Mt. Washington or Mt. Cenis inclines, to undertake such a feat is to invite disaster.

The legitimate field which is now open to the electrically driven street-car is surely extensive enough without encroaching upon territory which legitimately belongs to the cable system. It is not good policy or good sense to make use of electric power in cases where it must compete, under unfavorable conditions, with directly applied steam power under favorable conditions. But this is precisely what is done, in effect, when we put inferior workmanship into electric motors, or when we attempt to use them in situations where an inclined cable system is obviously a much more safe and economical one.

ELECTRICAL LITIGATION.

THE year 1887 closes with a considerable amount of litigation going on in connection with electrical patents, although few, if any, cases of importance have been concluded during the year. At the time of writing, the Supreme Court has not delivered its decision in the Bell Telephone cases, although it has been anxiously expected for the last three months by the various parties in interest. The long delay would seem, if anything, to be an indication that the court will affirm the validity of the patents. If a sufficient defense were found among the many urged by the various defendants it would not be necessary to consider other points at length, whereas in preparing an opinion sustaining the patents, the court might consider every point carefully and at length, a proceeding, which in view of the enormous volume of evidence, would necessarily occupy much time.

The suit of the Western Union against the Baltimore

and Ohio Telegraph Co. for infringement of the Stearns condenser patent, is likely to be terminated by a decree by consent of defendants, a result which in view of the recent union of the two companies can hardly be said to be unexpected. It is reported that Mr. Van Hoevenbergh, late electrician of the Baltimore and Ohio, who was made a defendant to the suit, has not yet consented to the decree, a circumstance which may have the effect of prolonging the litigation.

The numerous suits brought by the Edison Electric Light Co. against the United States, Westinghouse, Consolidated, and other companies engaged in incandescent electric lighting, have apparently made but little progress during the year. In most of these cases the defendants have filed pleas, alleging that the Edison patents have expired, and that the present Edison company, which, it will be remembered, was formed by the consolidation of the original company with some of its sub-companies, has no legal standing in the present litigation.

The suit of the Thomson-Houston against the American Electric Manufacturing Co., alleging infringement of Professor Thomson's patent for automatic regulator for arc-light dynamos, is in progress, a considerable amount of testimony having been taken.

The suit brought by the Brush company against certain users of apparatus of the Fort Wayne Jenney Co. for infringement of the Brush arc-lamp patents, has been vigorously contested. The testimony has been completed, and the case, having been argued early in December, is now awaiting decision.

The suits brought by the United States Electric Lighting Co. against the Edison company alleging infringement upon Farmer's patent for regulating apparatus for multiple-arc circuits, are making slow progress, the testimony for the defense being yet unfinished.

Two suits have been instituted by the Westinghouse Electric Co. on the Gaulard & Gibbs patent for induction lighting by alternate currents, one against the Sun Electric Co. of Woburn, Mass., in which the evidence has been completed and the case prepared for argument, and the other against the United States Illuminating Co., of New York, in which no evidence has yet been taken.

Another action for infringement, which has been commenced but in which no evidence has been taken, is that of the Consolidated Electric Light Co. against the McKeesport, Penn., Light Co. This is a very important case, as it is designed to determine the validity of the Sawyer-Man patent claiming the exclusive right to the incandescent filament of carbonized fibre, which is employed by the Edison company as well as by most other manufacturers of incandescent lamps.

An action has also been commenced by the Brush company against the Faraday Carbon Co. of Pittsburgh, alleging infringement of Brush's patent for copper-plated carbons. A suit on the same subject was commenced by it some years ago against the United States company, but was dropped and never brought to an issue. A movement is said to be on foot among the manufacturers of carbon points to make common cause with the Faraday company in its defense.

Quite a number of other suits of minor importance are now pending in the courts in which electrical devices are involved, but the above list comprises the most important ones. It is probable that the present year will be marked by the decision of a number of important patent cases, which will have a marked influence upon the future direction of electrical development.

A TIMELY WORD OF CAUTION.

In a recently published article, a valued contributor pointed out in a forcible manner the dangers of ignorant engineering and of cheap construction in attempting to deal with the tremendous electrical forces which are coming into everyday use in connection with electric lighting and power distribution. It is impossible to lay too much stress upon this vitally important matter. No one who reads the daily journals can fail to have remarked the increasing frequency of fatal accidents from electric currents. At the same time nothing can be more certain than that almost without exception these casualities are due to the reckless manner in which unprotected conductors, charged with death-dealing electric currents, are placed in public thoroughfares, and in the vicinity of telegraph, telephone and other domestic service wires. We have no disposition to assume the role of alarmists in this matter; on the contrary, we are fully persuaded that with reasonable precautions there is no known agent for producing light or applying power, which in respect to absolute safety to life and property is comparable to electricity. But for this very reason it is all the more important that electricity should not receive an undeserved ill-reputation at the hands of its professed friends.

One need not go a thousand miles from New York to meet with flagrant examples of the dangerous practices to which we refer, while the too voluminous catalogue of accidents to persons and property reported from other parts of the country, show that the cause of complaint is not local but general. We referred some time since to some of the shortcomings of electric railway constructors in this direction, and are pleased to note that a marked change for the better is already observable. Nevertheless, it will hardly be credited that among the recently constructed electric street-railway lines is one in which the main electric conductors, designed to work with a potential difference of 500 volts, are extended for three or four miles, insulated from each other and from the earth only by the wooden poles, 100 or so to the mile, to which the conductors are secured by iron brackets only a few inches apart. Old electricians have not forgotten the exploits of the anti-insulation crank. They remember the competitive telegraph line which he built between New York and Boston, "before the war," and how he came to the front again in the local telephone service, and demonstrated that, the smaller the wire and the less the insulation, the better it served to convey the tones of the human voice, but they did hope that he would not attempt to carry out his theories with dynamo-electric currents. Nevertheless, he comes up smiling, as usual, but we shall try to keep an eye upon him.

While upon this subject, it is but a simple matter of justice to the Edison Electric Light Co. to say that from the commencement of its operations, it has insisted

upon and endeavored faithfully to maintain the highest standard of excellence in constructive details in the numerous plants which it has installed. Whatever of technical excellence is found in American practice, relating to electrical distribution, is unquestionably due in no small measure to the example set by this company, and to the influence of men who have received their training in its service. We want to see a like standard of excellence and safety extended to every department of electrical distribution, and shall use our best endeavors to that end.

THE TELEGRAPHIC SERVICE.

It is very hard to please some people. When the Baltimore and Ohio telegraphic system was purchased by the Western Union Company, a tremendous cry of "monopoly" was raised in the newspapers, and predictions were freely made that tariffs would be raised at once, in order that the public might be made to foot the bills for the telegraph war of the last three years. On December 2, a reduced schedule for a portion of its territory was announced by the Western Union, whereupon the anti-monopoly papers hastened to denounce this action with equal vigor as an attempt to head off any movement which the people's representatives in Congress might make to pass a government telegraph bill during the present session. Such a measure would unquestionably have the effect of converting the present surplus into a deficit, which seems to be one of the principal objects aimed at by a certain class of statesmen, but whether it would improve the telegraphic service is by no means so certain.

Notwithstanding the assertions to the contrary which are constantly reiterated by those who ought to know better, the facts are that the average charge per message has become less and less every year, and considering the distances covered and the facilities afforded, telegraphic service is cheaper in the United States to-day than in any country in the world. The Western Union report for 1887 shows that its average receipts per message amounted to 30.25 cents, being only half as much as it was no longer ago than 1874. It would be hard to point to a correspondingly great reduction in any other branch of public service.

In our opinion the ground of complaint lies wholly in another direction. The duplex, quadruplex, automatic, and other improved methods of working, have simply had the effect of reducing the cost of the service, and possibly of expediting it in some small measure. The result is that while the cost of sending telegrams is much less than formerly and the convenience greater, owing to the great number of offices and the introduction of the free "call-boxes" in the larger towns, there has been no very marked improvement in the celerity of the service, while in point of accuracy it has unquestionably retrograded. With the quadruplex and automatic apparatus, and the high pressure speed at which operators are now expected to work, there is far more occasion for "guess-work" on the part of the receiver and far less opportunity for inquiry and correction than formerly. Immature boys and girls, having no knowledge of general business, and with little or no sense of responsibility, are now preferred to the more careful and experienced operators of a former day, for the two-fold reason that they will "get off more business in a day" and do it for smaller wages. These causes, among others, have led to a distinct deterioration in the quality of the service. This deterioration manifests itself in two principal ways. One of these, the increased percentage of words erroneously rendered or misspelled, is patent to every one who makes extensive use of the telegraph, and the other, though less apparent is even more serious. We refer to the want of appreciation of the confidential character of the service. The old-time operator, even though, as in some instances he was, a tippler, a gambler, and little better than a vagabond, was rarely destitute of a certain professional pride, which ensured the sacred inviolability of every message that passed through his hands. We are now too frequently reminded of the greater laxity of modern methods by instances tending to prove, though of course not proving, the truth of the cynical adage, that "every man has his price."

What we would like to see is an increased sense of responsibility on the part of the managers of telegraph companies and of their employés, in respect to matters of this kind. There are large numbers of boys and girls in this city to-day, through whose hands pass business and social messages involving interests of the utmost importance, who never having had their attention called thereto, are utterly ignorant of the fact that it is a misdemeanor of the gravest character to give information respecting the contents, character or even existence of any particular telegram, a thing which ought to be impressed with all possible force on the mind of each and every candidate for a position in the telegraphic service.

In other words, let the telegraph operator, in this as in other particulars, be treated more like a rational human being and less like a mere attachment to a key and sounder.

The United States Electric Lighting Company announces through the columns of the *Western Electrician* that it possesses incomparably the best high tension alternating or secondary generator system extant, which is covered by fundamental patents, not used for advertising purposes but for the protection of its customers. It also cautions the public against parties posing before the public with "so-called alternating systems," and claiming rights under the Gaulard & Gibbs patent. We learn from this announcement that the last named system, having been found to be "impractical" has been abandoned, and that the parties referred to are infringing upon patents owned by the United States company, and are substituting such infringing apparatus for their own uncommercial and discarded system. If this is true, it is certainly much to be regretted. As the itinerant gospeller said, when denouncing the authorities of a certain town for the prevalence of immorality and crime in their bailiwick:—"And these proceedings are permitted to go on unchecked, in this *so-called* nineteenth century!"

An opportunity is now offered to those who invested in the stock of the People's Telephone Co., and who are tired of waiting for the decision of the Supreme Court at Washington, to put them, so to speak, out of their misery, which will enable them to send good money after bad, as the proverb has it. The sage of Yellow-Breeches Creek is reported to have evolved an invention which renders the softest footfall audible at a distance of many miles, and is confidently expected to put an end to the reprehensible practice, common alike in rural and urban communities, known as "bein' out o' nights." He might next turn his attention to inventing something or other for the benefit of that somewhat numerous class of the community, which "don't know enough to go in when it rains," and which has aided so liberally in bringing his previous achievements to the notice of a discriminating public.

ARTICLES.

TRANSMITTING SPEECH BY INTERRUPTED ELECTRICAL CURRENTS.

BY C. J. KINTNER.

(Late Principal Examiner Class of Electricity, U. S. Patent Office.)

(Continued from page 468.)

The contact telephone which depends for its mode of operation upon the variation of the actual contact surfaces between the electrodes, differs from the magneto instrument in that, the currents always move, so to speak, in one direction, there being only a rise and fall or change of volume due to a constant electromotive force or tension and a varying resistance, the effect on the receiver being the equivalent of the reverse currents, which arise in a magneto transmitter.

A diagram representing the current waves of such a transmitter will therefore be unnecessary, it being understood that such a diagram would show simply increased and decreased volumes for the overtones and fundamentals due to a current of constant electromotive-force where the diaphragm in figure 2 shows increased currents, decreased currents and reversals. (See the ELECTRICAL ENGINEER, vol. 6, No. 72, p. 467.)

Figure 1 represented diagrammatically the volumes of current for a pure musical tone when uttered into a Bell magneto instrument.

The composite tones differ in the main only in degree from the pure tones, and if the instrument be so modified as to meet this change of degree it will meet all the requirements necessary to transmit such composite tones. Very much has been said during the telephone controversy of tone quality and its two companion elements, pitch and intensity. It has been urged with good success, that there is an absolute necessity in the transmission of articulate speech that the timbre or tone quality be transmitted, but so far as I am aware it has never been pointed out that this tone quality is purely a matter of degree; that the voice of one person differs from another only in degree of musical purity, and that the instrument which will transmit one voice will not successfully transmit another in all its purity.

It has been the argument of the learned counsel in the Bell suits, that it was absolutely necessary that the transmitting diaphragm should so mould the electrical currents on the line as to create actual copies in the receiver at the distant station, and the magneto instrument does it beyond a peradventure of a doubt. This argument is undoubtedly correct for telephones of that type.

If, then, as I have asserted, individual voices differ from each other only in their degree of musical purity, and no one can doubt it who has listened to the smooth liquid voice of the Italian or Frenchman as compared with the guttural hoarse voice of the German; if such be the case, and if the Reis instrument transmits pure tones by current impulses of constant volume, then why cannot this instru-

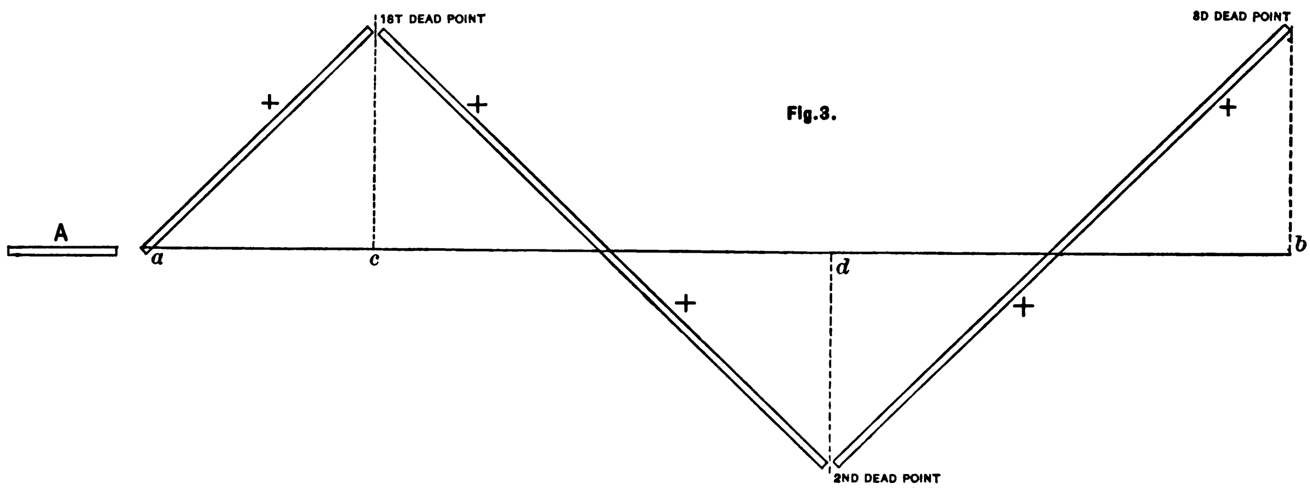


Fig. 3.

Figure 3 represents the same for a Reis transmitter, *a*, *b*, being the medial line of the diaphragm at rest, and A the volume of current flowing under all conditions. In a word, as there are no overtones and the beats or vibrations are regular, the electrodes being of hard metal as iridium, there will occur at the fundamental and sole dead points of the diaphragm, breaks in the current in regular recurrence.

A constant volume of current will flow for all phases of the diaphragm equal to A, and electrical impulses will be set up over the line of equal volume and duration which in turn will actuate the receiver and cause it to repeat accurately this fundamental tone. It is not possible that there can be current variations between absolutely clean hard iridium contacts, for the individual molecules are so small or so compact that for the infinitesimally small power of a delicate pure musical tone, such a proposition is absurd. I think, however, if proof be demanded, that such pure tones are transmitted otherwise than by individual current impulses, the Gray system of unison reeds will substantiate it.

If, then, a pure musical tone can be transmitted by current impulses, why cannot composite tones? What is the difference between these two classes of tones that one can be transmitted by the Reis instrument, while the other cannot?

ment be so adjusted as to transmit such composite musical tones; and has it not been done in the past by scientists unconscious of the actual mode of operation? It is, I think, generally admitted that speech can be transmitted by the Reis transmitting apparatus, but it is urged that the Bell method is practiced whenever such result is attained; that there has been current variation between the electrodes rather than actual makes and breaks, and much has been said about continuity of contact through the spark if actual mechanical separation took place between the electrodes.

In figure 4, I have shown a diagram of the current impulses created in a Reis transmitter when adjusted to transmit the same composite sounds shown by the diagram in connection with a Bell magneto shown in figure 2 (see ELECTRICAL ENGINEER, vol. 6, No. 72, p. 468). *a*, *b*, represents the medial line of the diaphragm as before, and A the current volume.

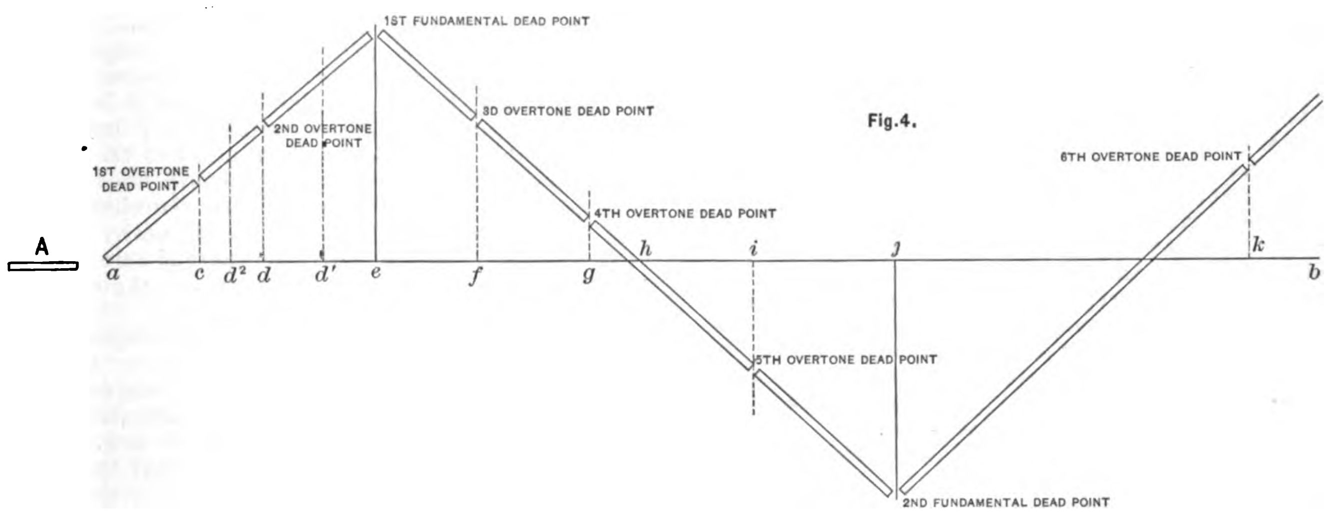
The diaphragm is under stress and is tuned to a given pitch, that of the normal voice of the speaker, and the movable electrode is a weighted lever adjusted to vibrate in absolute unison with the diaphragm under all conditions. That is to say, if the diaphragm makes 200 vibrations per second, the loose electrode of pendulum form will vibrate absolutely with it, separating from it only by virtue of its inertia, as the diaphragm tends to recede from it at the

reverse overtone and fundamental dead points. As a result we have actual mechanical separations at *c* and *d* for the first and second overtones and at the first fundamental. There will be no separation for the advance overtones or such as increase or aid the fundamentals, and hence these overtones will be lost. It is true the speech may be somewhat mutilated, but for all overtones where the tendency is to decrease the fundamentals there will be a separation of the electrodes and the receiver will be affected thereby, the current volume always remaining constant and the impulses copying the reverse overtones.

It may be urged that if we neglect the advance overtones, or such as aid the fundamentals we neglect much of the transmitting current impulses, and hence mutilate the speech so as to make it more or less unintelligible.

Such is not the case, and I am convinced that with existing contact telephones it is only the action of such tones as actually check the advance of the diaphragm that gives the actual tone qualities, and that the advance, or aiding overtones, do little to modify the tones in the receiver.

The instrument used by me in my experiments consisted of a rectangular diaphragm about three inches long by two and one-half in width, held at its ends by means for regulating its tension; near its centre was a polished steel electrode. This diaphragm hung in its frame so as to adapt it to be adjusted to any angle. The loose electrode of hard steel hung from pivots like a pendulum and was provided with a pendulum bob for adjustment. By adjusting the diaphragm to a given pitch and the weight or bob on the loose pendulum electrode so that it would vibrate in unison for a given note, I found that on uttering the word "hello," into the instrument, only unintelligible disagreeable sounds were heard until I struck the key to which the diaphragm was tuned, when the attendant heard it very plainly and continued to hear it until the pitch of my voice was changed, when only confused sounds were again heard.



If the apparatus operated by the Bell method, why would it not operate when the voice was pitched in a different key? There can be but one solution of the problem, and that is, that the electrodes vibrated in unison with the key note of the voice, separating for all the radical phases of its overtones and fundamentals. It is absurd to suppose that there can be such a phenomenon as current variation due to pressure between two hard polished steel electrodes under pressure of so delicate a force as the sound waves of the human voice, as it is equally absurd to suppose that there lies in the spark, if a spark does in fact exist between such electrodes when separated, an inherent self-acting force which so modifies the electrical currents as to make them of a wave or undulating nature. With a delicate microphone transmitter having variable contact surfaces, as in the Hunnings instrument, such a thing is admissible and entirely in harmony with the operation of the magneto apparatus, for in such an instrument there is clearly a change of conductivity due to this change of pressure.

Whether or not such a contact telephone as I have described is practical, is another question which need not be discussed here; the simple fact that with such an instrument intelligible speech can be transmitted by current impulses being the question under consideration. That it does it, and in the manner described is clear, and that the Reis instruments, wherever operating to transmit speech, do it similarly, is also, an undoubted fact in my opinion.

PHENOMENA OF RETARDATION IN THE INDUCTION COIL.[1]

BY WM. STANLEY, JR.

This paper will attempt to emphasize the time relations of the alternating E. M. F.'s. and currents in the induction coil. Any description of the phenomena of retardation accompanying the inductive effects of currents would necessarily be incomplete and unintelligible without a clear conception of the fundamental principles of the induction coil. This must be my excuse for briefly recalling to you the rudiments of the induction system.

An alternating E. M. F. differs from a direct E. M. F. in two important points: It varies continuously, and its direction or polar tendencies alternate.

To illustrate graphically the various values of an alternating E. M. F. and the attending phenomena, it is usual to plot a series of curves above and below a straight line.

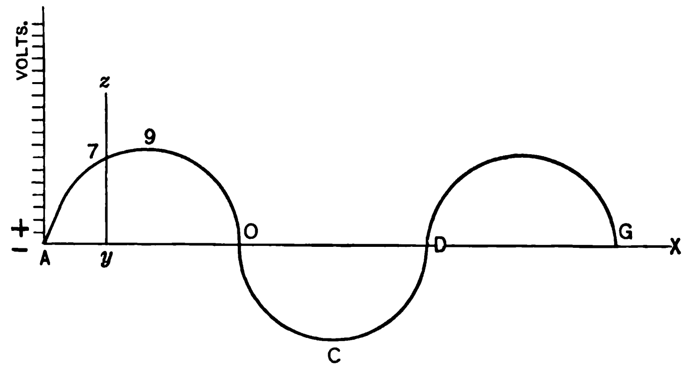


Fig.1.

This line, when divided in equal divisions, may be taken to represent successive periods of time, as in figure 1. Starting at the point A, the E. M. F. is seen to rise rapidly above the line A X in a gentle curve (the particular curvature of

1. Read before the American Institute of Electrical Engineers, New York, Dec. 6, 1887.

which depends on the construction of the generator), until at 9 it reaches its highest point; thence it flows downward in a similar but reverse curve, until it again reaches the line A X, and, continuing downward, finally attains a sub-maximum at C. From this point it rises again, crossing the line A X once more at D, whence a repetition of the former curves occur.

The E. M. F. of the alternating current at any particular time can be determined by the distance of the curved line above or below A X at that time. For instance, suppose we wish to determine the E. M. F. at any time, y. Through y draw $y\ z$ perpendicular to A X, cutting A 9 at 7. Then 7 y represents the E. M. F. applied to the circuit at the time y.

From an examination of the curve it will be seen that at stated intervals of time A, O, D, G, there is no E. M F. applied to the circuit; and, if the curves above the line A X

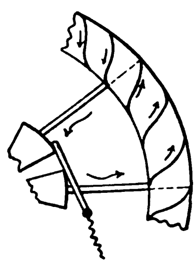


Fig.2.

represent E. M. F's applied in one direction, those below the line A X represent E. M. F.'s in the opposite direction. Hence adjacent E. M. F's alternate in direction, and hence the term alternating currents.

There is a general misunderstanding to the effect that the alternate current dynamo is less economical than is the direct current generator. This is not so; there is a little difference, it is true, but the difference is, I believe, in favor of the alternate current machine. Let us take a dynamo field, for example, that of a simple direct current type of dynamo, and separately excite it with a constant current; let us now wind two armatures of identical dimensions, one for direct and one for alternate currents, and arrange to run them at the same speed; and let the windings of the two armatures be identical in size and number of turns of wire. Now the E. M. F. produced in these two armatures will be found to be, for the direct current armature:

E. M. F.	X volts.
Resistance of the armature.....	R ohms.
Amperes per section of winding...	A amperes.

And because the armatures are identical we have for the alternate current dynamo:

E. M. F.	2 X volts.
Resistance of armature....................	4 R ohms.
Amperes per section of conductor	½ A amperes.

Thus the direct current dynamo will generate A X watts, and the alternate current dynamo $2\ X \times \frac{A}{2}$, or A X watts, also. Hence the capacities of the armatures are equal.

The loss of energy in the armatures will be, for the direct current dynamo, $A^2\ R$ watts. For the alternate current dynamo $\left(\frac{A}{2}\right)^2 \times 4\ R$, equals $\frac{4\ A^2\ R}{4}$, or $A^2\ R$ watts. From this we learn that the losses in the armatures are equal. It is stated, however, that owing to self-induction, Foucault currents, or something else, these figures do not represent the actual waste of energy. The waste of energy by self-induction in the direct current dynamo occurs when a brush on the commutator touches two adjacent strips at the same time, as in figure 2. The arrows indicate the direction of the induced currents, and show that at that time all the E. M. F. of the short circuited coil is wasting current on a short circuit through the brush. What now is the loss in the alternate current dynamo through self-induction?

In the direct current dynamo the current flowing through the armature coils magnetizes the armature with a polar line at an angle to the polar line of the field. These armature poles maintain a constant position relative to a fixed point, and are of a constant value. In the alternate current dynamo, the current in the armature rises above and falls below a zero value periodically; hence the iron in the armature has periodic polar tendencies at an angle to the polar line of the field.

I shall endeavor to show that instead of wasting energy by periodically polarizing the armature, the E. M. F. devoted to this purpose is at first temporarily stored and subsequently returned. As is well known, a certain period of time is required to establish a given magnetic charge in iron, which time is directly proportional to the degree of magnetization to be attained. If, therefore, we plot a curve, the abscissæ representing time and the ordinates the degree of magnetization, and if we apply this curve to the curve of E. M. F. producing it, we have two similar curves separated from one another by a given period of time, as shown in figure 3, where 1, 2, 3, 4, 5, represents the curve of E. M. F., and 6, 7, 8, 9, 10, the corresponding curve of magnetization.

When the coil on the alternate current armature leaves a pole of the field during rotation, the lines of force threading it rapidly diminish, and by induction generate an E. M. F. in the coil. The rise of E. M. F. and consequent flow of current in the coil is attended by a magnetic polar effect in the iron core, which not only increases while the E. M. F. is rising from 1 to 2, but continues to increase, attaining its maximum value when the E. M. F. has fallen to K. Up to this time, namely, the time when the magnetic charge is maximum, energy has been expended upon the iron core; but notice, that at this time the charge on the iron core is superior to the charge producable by the E. M. F. at that instant; consequently, the charged core does positive work upon the E. M. F., if I may use the expression, and in doing this decreases its own value.

This auxiliary E. M. F. developed by the magnetized core upon the armature conductor assists the E. M. F. proper; that is the E. M. F. developed by the field magnets. Thus the energy devoted to magnetizing the armature, during the rise of wave of E. M. F., is returned as E. M. F. during the fall of potential. We may assume that the wave is

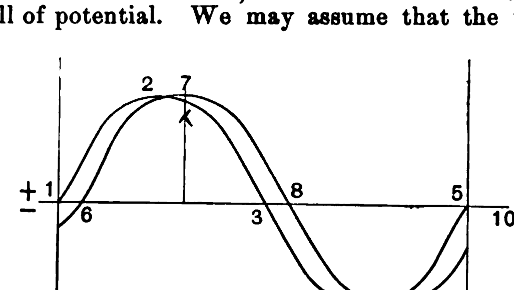


Fig.3.

shifted along or retarded. Figure 3 illustrates this retardation. 1, 2, 3, 4, 5, is the curve representing the position of a wave of E. M. F., without taking into consideration the effect of the iron core, while 6, 7, 8, 9, 10 is the curve-wave of E. M. F. which has been retarded, by reason of the magnetic charge on the iron from the theoretical position, 1, 2, 3, 4, 5.

The curve of E. M. F. of a coreless armature is quite different; here, as before, the theoretical curve is A, B, C, D, E, figure 4. Let us see what the effect of self-induction is in this case.

We know that self-induction is proportional, among other things, to the current flowing at a given time. Now, at the time A, no current flows; hence, there is not self-induction. But as the E. M. F. rises, and the current is driven

through the coil, the self-induction or counter E. M. F. prevents the E. M. F. from attaining its theoretical value. It does not delay the E. M. F. from its theoretical time position, as is the case with an iron core, but prevents the E. M. F. from attaining its theoretical maximum value at any time. The real curve of E. M. F. in this case would be A, G, C, H, E, figure 4. This curve shows that there is no waste of energy due to counter E. M. F., but that the armature output is reduced by self-induction. An iron core, therefore, causes the counter E. M. F. to oppose the E. M. F. proper only during one-half a period, and allows it also to assist the E. M. F. proper during the other half period in the phase.

It is evident that the time of retardation, viz., the distance between 1, 2, 3, 4, 5 and 6, 7, 8, 9, 10, figure 3, de-

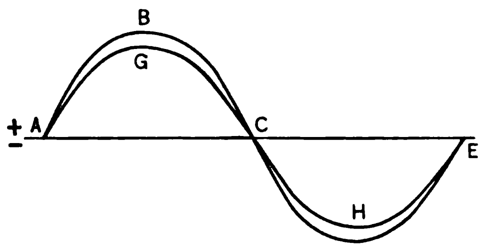


Fig.4.

pends on the quantity of current flowing through the armature coils as well as on the core. I have described this point at length, as there is a general, although false, impression that the iron core of an alternating armature necessarily wastes energy.

We may roughly compare the theoretical efficiencies of the direct and alternating dynamos, as follows: The output is equal; the waste of energy in armatures due to c^2 R is equal. The waste due to self-induction is greater for direct than alternating dynamos, with properly constructed iron cores.

Faraday's law of induction may be stated as follows: The variation of the magnetic field surrounding a conductor induces an E. M. F. in that conductor. A variable field is produced by a variable current, and hence, a conductor carrying an alternating current will induce an E. M. F. in another conductor residing in the same field.

Let us note the values of the E. M. F.'s in the inducing or primary, and induced or secondary circuits, at the same time, and first when no current is flowing. The curve, A, B, C, D, E, figure 5, represents, as before, the alternating applied E. M. F. Now, the induced E. M. F. will be a maximum at the time when the inductive effect of the primary current is a maximum, and the inductive effect of the primary will be greatest when its E. M. F. is changing most rapidly. Evidently this will occur near the zero line A X; for the E. M. F. will vary greatest when passing from a finite value to zero, or from zero to any finite value. Hence the inductive effect of the primary and the E. M. F. developed on the secondary circuit will be a maximum when the primary E. M. F. is least.

Figure 5 represents the time relation of the primary and secondary E. M. F.'s when no current is passing. The position of maximum E. M. F. of the secondary is, as you see, one-fourth of a complete period behind that of the primary. Now, a moment's consideration will show that the secondary circuit is simply the receptacle of an E. M. F., and, when no current is flowing in it, plays no part in the inductive phenomena.

The primary circuit evidently will induce in itself an E. M. F. in the same manner that it impresses the E. M. F. on the secondary circuit. Hence, in any circuit to which is applied an alternating E. M. F., we have two phases of E. M. F.; the one, the applied; the other, the self-imposed; the points of equal value in each being distant from each other one-fourth of a complete period, when practically no current is flowing. This self-impressed E. M. F. is called "self-induction," or counter E. M. F. When two or more coils are wound together so as to act collectively, the effect of the one upon the other is termed "mutual" induction. We now see why, when an alternating E. M. F., of, say, 1,000 volts, is suddenly applied to a coil whose resistance is low, as, say, 1 ohm, the coil does not receive the quantity of current destined for it by Ohm's law. The kinetic E. M. F. is very small, because it is the difference between the applied and counter E. M. F.'s.

Figure 6 shows a wire wound on itself or coiled. The full arrows indicate the direction of the applied E. M. F., the dotted arrows the counter E. M. F. In the two adjacent turns one impresses a counter E. M. F. on itself, and also a counter E. M. F. on the other and the other impresses a counter E. M. F. on itself and on the former. Hence in two coils of wire we have four impressed counter E. M. F.'s. This is commonly stated as the self-induction, and is proportional to the square of the number of turns.

We will now consider the time position of the currents flowing through coils impelled by the E. M. F.'s of which we have spoken, and endeavor to apply the effects of the various positions they assume to a few of the phenomena noticed in working induction coils with different current strengths.

Evidently, when little current is flowing over a conductor, the self-induction and retardation are small; hence the curve of the current nearly coincides with the curve of E. M. F. Figure 7 illustrates the positions. Here the phase of the primary current nearly coincides with the phase of its E. M. F. The curve of the secondary E. M. F. is, however, just one-fourth of a period later than the primary current phase, while the curve of the secondary current is still farther behind it; so that, while the primary current phase is x distance behind the primary E. M. F. phase, the secondary current phase is 2x plus one-fourth of a period behind the primary E. M. F. phase. This delay reacts on the primary E. M. F. The lower curve in figure 7 is the curve of the counter E. M. F. developed by the

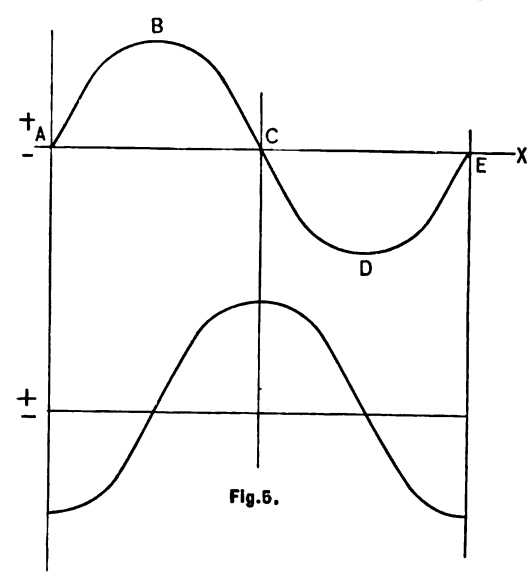


Fig.5.

secondary current upon the primary circuit. It will be noticed that it no longer exactly opposes the phase of the applied E. M. F., for the time line AB, passing through the maximum position of the primary E. M. F., cuts the counter E. M. F. curve at a point before its maximum value is attained.

Figure 8 shows an extreme case. Here the curve of the primary current is one-eighth of a period behind its E. M. F. Consequently, the curve of secondary current is one-half a period behind the primary E. M. F., *i e*, $\frac{1}{8} \times 2 + \frac{1}{4}$; and the curve of counter E. M. F. developed by the secondary current is $\frac{3}{4}$ of a period behind the primary E. M. F.

We are now prepared to understand why the counter E. M. F. developed in the induction coil varies in its counter effect as current is abstracted from the coil The reason is simply that its position of counter effect is dependent on the curve of its producing current, and as the current occupies a variable position relative to the applied E. M. F., the counter E. M. F. successively occupies positions of lesser counter effect until eventually it has no counter effect whatever.

These phenomena are taken advantage of in the operation of induction coils. If a constant E. M. F. be applied

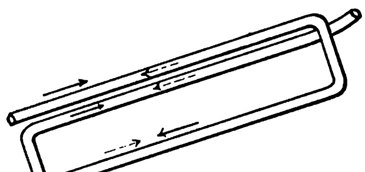


Fig.6.

to the primary circuit of a converter, successive increments of current will be allowed to occupy this primary circuit, as successive quantities of current are abstracted from the secondary circuit; because these currents push along out of the way the opposing counter E. M. F., and consequently the kinetic E. M. F. attains correspondingly greater values.

Thus far we have considered only two factors of self-induction and retardation, viz., the number of turns of the conductor, and the quantity of current flowing; but there is another factor, most important, and that is, the resistance of the magnetic circuit.

The magnetic resistance of iron is, as you know, similar to the resistance of any other conductor, in that it is directly proportional to the length, and inversely proportional to the sectional area of the circuit. This, however, is only true for limited values of magnetism. As the magnetic lines traverse a core they encounter a resistance proportional to their number at first; but if more lines be continuously

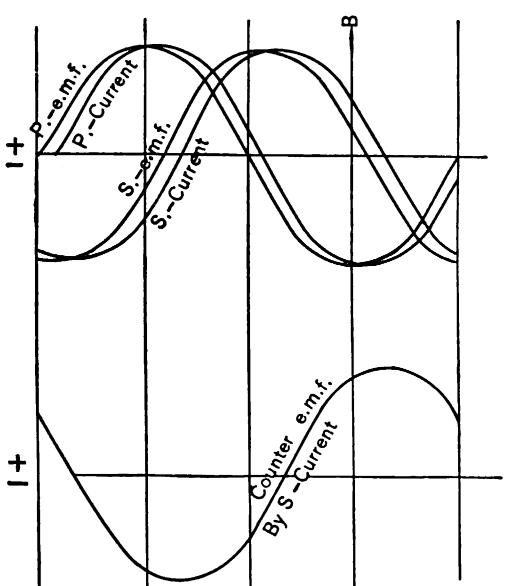


Fig.7.

added, a number is eventually reached which the iron utterly refuses to carry. This degree of magnetism is termed "saturation."

It can be shown that the position of the curve of counter E. M. F. is directly connected with the degree of saturation of the core, so that with a given coil the position of no counter effect of the counter E. M. F. coincides with saturation of the core. The magnetic resistance of the core of an induction coil determines, then, the limit of retardation or lag of the current phase. Hence, if we wish to construct a coil in which the counter E. M. F. shall always be inversely proportional, and the kinetic, applied E. M. F., always directly proportional to the current abstracted from it, we make the core of the coil with the lowest possible magnetic resistance. Such a coil, when supplied with a constant difference of potential, will furnish at its secondary terminals an approximately constant E. M. F. It is also evident that a coil having a limited section of core supplied with a constant current may deliver a constant

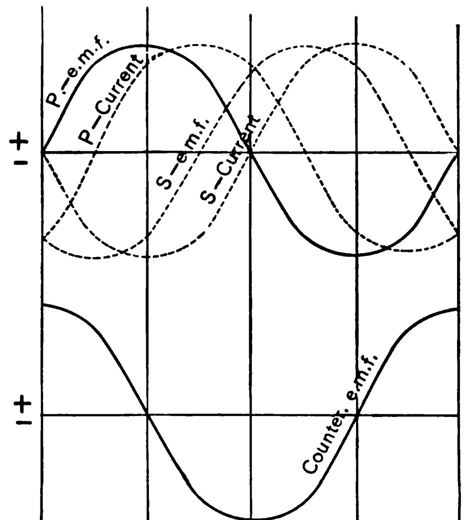


Fig.8.

E. M. F. on its secondary terminals, provided the field produced by the constant current is sufficient to saturate the core.

I noticed these phenomena several years ago when experimenting with a series system for lighting. Mr. O. B. Shallenberger has applied this saturation effect in a most striking manner. He connects a number of incandescent lamps, say four, in series attaching their outer terminals to a source of constant alternating E. M. F. (figure 9). Around each lamp is shunted a self-induction coil, so proportioned that an E. M. F. of say 100 volts will saturate the

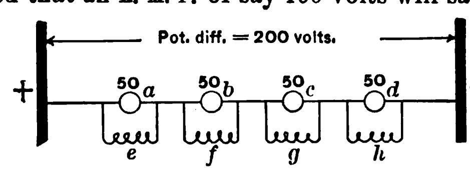


Fig. 9.

core of the coil. If, now, a lamp be turned off, its current is diverted through the shunted coil, which offers a counter E. M. F. of 100 volts. We would naturally expect that the light in the remaining lamps would grow dim, but this is not the case. If we measure the difference of potential on the extreme terminals of the lamps we find it to be 200 volts; on the three burning lamps it is 50 volts each, while on the shunted coil it is 100 volts; so that the sum of the potentials of the three lamps and the coil is 250

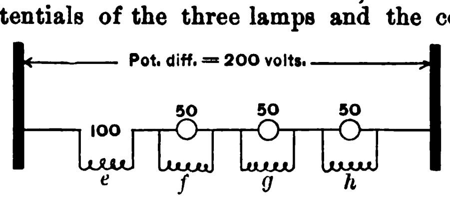


Fig. 10.

volts, while the applied E. M. F. is but 200 volts (figure 10).

I think the explanation of this is as follows: During the first part of the rise of the E. M. F. wave, the shunt coil practically offers an infinite counter E. M. F., in comparison with which the resistance of the lamp may be neglected; when, however, the applied E. M. F. has attained a value of 100 volts, this counter E. M. F. is surmounted, because the core of the coil is saturated by the current flowing in the coil.

The lamps, therefore, receive the remaining 100 of the

200 volts applied, since the coil, being saturated, offers no additional counter effect. Now, after the wave of E. M. F. has declined to a value less than 100 volts, the stored magnetism in the core of the shunted coil begins to lose strength, and in so doing, develops an additional E. M. F., which, assisting the generator current, furnishes a current during the time the applied E. M. F. is of low, or zero, value, and by so doing keeps the average E. M. F. on the lamps constant.

It is necessary then, in working with alternate currents, to take into consideration the time retardation or lag of the current behind the E. M. F. We have seen that this lag is dependent on the resistance of the core, and on its degree of magnetization. I have found it especially necessary to make time corrections in work on alternate current motors, and in apparatus depending on the attraction or repulsion of magnets energized by alternate currents.

I have stated that there is no loss due to the periodic magnetization of iron cores by an alternating current. This is only true of a perfectly subdivided core. A solid core allows secondary currents to flow. Hence its storage capacity is lowered. In practice, the loss due to wasted currents in laminated cores can be kept as low as one per cent.

We may summarize the effects of the retardation of currents behind the E. M. F's. in the induction coil as follows:

Retardation causes the counter E. M. F. developed to have counter values inversely as the quantity of current flowing in the coil.

Retardation causes the energy expended in magnetization during the increase or development of a current to be returned as current energy during the subsidence of the current.

To an alternating or similar current, iron offers true storage capacity for all values of magnetization below the saturation limit.

REVISION OF THE PATENT LAW.[1]

BY ARTHUR STEUART.

General Counsel of the National Electric Light Association, Baltimore.

I COME before you this evening at the invitation of your secretary, for the purpose of telling you of the effort that is being made by the National Electric Light Association to secure some reforms in the patent laws of this country, and of attempting to get you to join hands with us in carrying these reforms into effect. I particularly desire that the suggestions I shall make may be fully discussed by those present, for I hope to gain many valuable suggestions from you. For the purpose, therefore, of presenting what I have to say in the shortest possible time, so as to leave as much as possible for other gentlemen, I have condensed my suggestions and shall state them with very little argument; first, for lack of time, and, secondly, that I think most of the reforms suggested are so apparent that they will call forth little opposition. But, before proceeding to discuss the details of the law that require changes and additions, I cannot refrain from making a few remarks upon the patent system in general and its influence upon the industrial development of our country. Who can measure the benefits that this land has derived from the inventions that have been produced by its citizens? The roll of honor is too long to be repeated. The cotton gin, the printing press, the reaper, the application of steam to all the uses of civilization, and, latest, but not least, the modern application of electricity in its multitudinous forms; but while these brilliant achievements occupy our attention, we must not overlook the thousands upon thousands of inventions relating to matters of detail in every industry that have cheapened the product by saving time, material, power or labor. The fact is apparent that our advancement as a manufacturing nation has been due to the introduction of new methods of work which have enabled us to produce staples at such a price as to compete with other nations in the markets of the world or in the development of new devices which have supplanted old ones or created a market for themselves. This being true, we must look for a cause for this development. What has induced the people of this country to create so many new things, to labor so long and arduously to lessen the cost of production of some articles, or to supply a new one to take its place which is better or cheaper?

I think we may state it as a proposition that will not meet with denial, that the prevailing motive of the American people is a motive of pecuniary gain, a desire to amass wealth, to attain power by means of money, and whatever avenue offers them this reward will be the one into which they will press with a vigor and determination that knows no such thing as failure.

When the framers of our constitution inserted into it the clause which provides that "Congress shall have power to promote the progress of science and the useful arts by securing * * * for limited times to * * * inventors the exclusive right to their * * * discoveries," they laid a foundation stone upon which an edifice has been constructed that has far surpassed anything they had conceived. Upon this provision of the constitution is our patent law based, from it it takes its spirit, and with the view of adhering more closely to this spirit have the amendments to the patent law been suggested to which I shall ask your attention this evening.

The patent laws of the United States passed in pursuance of this provision of the constitution open up before every citizen of this country, as well as before those of many others, opportunities of obtaining wealth and power that are not presented by any other set of circumstances under the sun. In a single moment of time by a quick operation of the mind the poor mechanic may be put into possession of an idea that by its own development may place him among the princes of the land.

This is the possibility that presents itself to every man, rich or poor, high or low, who comes to understand the meaning of our patent system and its results.

What force can be compared with this to produce in the minds of men, thought, deep, concentrated and continuous, for the production of inventions, a thirst for knowledge and a frugality of life that will supply a surplus of funds for the acquisition of knowledge and the development of inventions, and an ambition for their children that they shall have greater advantages of education upon which to work than their parents? And who can estimate the value to a state of such influence upon its citizens. This training, foreign manufacturers testify, produces in American operatives a power of comprehending their work and a rapidity and dexterity of workmanship that makes it impossible for them, with labor at one-half the cost, and their factories fitted with the latest American machines, to produce the same goods as cheaply as they can be produced in this country.

It therefore goes without saying that with such an inestimable good to the nation, both in improving its industries and its people, to be attained by stimulating inventors to their highest effort, the only true course for the law makers to pursue in framing legislation relative to this subject, is to endeavor to make the process of obtaining a patent upon an invention as quick, easy and inexpensive as possible, and after it is granted to throw around it in the hands of its owner every form of protection known to the law, that will enable him to realize the full intent of the constitution and enjoy the exclusive right to make, use and vend the invention.

Our patent system as it exists to-day is a grand structure, but it has some defects which are due principally to the fact that the demands made upon it by the development

1. Read before the American Institute of Electrical Engineers, New York, Dec. 20th, 1887.

of our industries have far exceeded anything that the framers of the present law contemplated.

The patent law of to-day is substantially identical with the law passed by Congress in 1836. This law was revised in 1870, and codified in 1874, but few changes were made in it, and little if any provision was made, to accommodate the immense mass of business that has been cast upon the Patent Office, and some of the new features that were introduced have been found to work a hardship upon inventors rather than a benefit. So that practically we are working under a law formulated 50 years ago, when the work of the Patent Office for the whole year was something less than it is to-day for each week. Is it surprising, therefore, that the child should have outgrown his clothes? And this is practically just what has taken place. A commissioner and a half dozen examiners were quite equal to the task of examining intelligently 450 patents a year, but the case is a very different one when the commissioner has under him something over 200 examiners, and when the annual issue of the office is something over 25,000 patents.

If time permitted, I would show you how utterly impossible it is for the work of the Patent Office to be accomplished with any degree of satisfaction to the public under the prevailing organization, but I know that most of you are quite as well aware as I am of the defects that exist, and are quite as much interested in removing them. I shall pass at once to the consideration of the measures of reform that seem desirable in the Patent Office.

I.—THE PATENT OFFICE SHOULD HAVE THE EXCLUSIVE USE OF ITS BUILDING.

All those who have had any experience with the internal operations of the Patent Office are aware of the fact that this office is greatly cramped for space. The examiners are often crowded into rooms that are so small that there is scarcely space enough between the desks to move about. Many of the officers and employés are compelled to work in quarters that are unfit for human habitation, simply because there is no other place to put them; and the documents and records of the office are so crowded, and the places in which they are kept are so unfit for their accommodation that they are in constant danger of destruction. The Patent Office building was constructed with money every dollar of which was paid to the government by patentees and applicants for patents, and yet the Patent Office is crowded into less than half of this building. The interior department, with its land office and Indian department, occupy the balance.

The interior department should have separate quarters and the Patent Office should have the whole of its building, which will not more than accommodate it.

II.—THE PATENT OFFICE SHOULD HAVE THE WHOLE OF ITS OWN INCOME.

For the past 50 years the Patent Office has paid all of its own expenses, has built its own building, and in addition to this has paid the government an annual revenue which aggregates to-day, without interest, something over $3,000,000. And yet the most difficult task that the commissioners of patents have had to perform has been to induce Congress to authorize the expenditure of a part of this revenue for the necessary expenses of the Patent Office. For the proper despatch of the work of the Patent Office considerable additional force is necessary. The commissioner of patents should be authorized to expend the whole of the income of the office for its own expenses, and what was not spent should be set aside as a fund to be used for the benefit of the office at any time that it is needed.

III.—EXAMINERS.

The staff of examiners in the Patent Office have charge of public interests of a most vital nature. They are the virtual judges of whether an inventor shall have a patent for his invention at all, and also of what kind of a patent he shall have in case they give him any.

It is therefore apparent that in order that they may perform their duties with intelligence and efficiency they must fulfill several conditions:

1st. They must be thoroughly educated in the technology of the arts and sciences and in the patent law. Experience has shown that this training can only be acquired in one of two ways, either by systematic teaching or by years of experience in the practical work of the Patent Office; the latter method is the one now in operation, and it results in creating a class of examiners who are undergoing the process of education at the expense of the unfortunate inventor whose case may fall into their hands. The inventors of the country have a right to demand that this system of education of examiners at their expense be discontinued and a system adopted that will secure to the Patent Office a corps of examiners who will be thoroughly trained before they enter the office, and to the inventor the examination of his case by a man fully equipped to make such examination in the best manner.

2d. Having obtained a staff of competent and thoroughly equipped examiners, they must be retained in office, so that the public may have the benefit of their services through a number of years. The army and navy have long since solved this problem by the exercise of a system of education, compensation, promotion and retirement on pay which fully secures these ends. Why should not that system so successful in one branch of the government service be established to secure similar and equally necessary results in the Patent Office?

3d. The examiners should be relieved from all political influence. Civil service reform has attacked the question of political interference with Patent Office appointments with little success. The evils from this cause now existing are great and call loudly for remedy. The army and navy system has put those departments of the public service almost entirely beyond the reach of the politicians. Thus it should be with the Patent Office.

IV.—SALARY OF COMMISSIONER OF PATENTS.

The salary of the commissioner of patents should be very high, so that every examiner may feel that if he is faithful and does his duty he may some day, in the natural order of promotion, reach a place of honor and large emoluments. This is the system of the army and navy, and in those departments it works admirably.

V.—A PATENT COURT SHOULD BE ESTABLISHED.

The greatest evil that exists to-day in the administration of the patent system, lies in the lack of harmony between the Patent Office and the courts of the United States in which infringement cases are determined. Every practitioner before the Patent Office knows how little regard is paid by the examiner to the decisions of the courts upon questions of patent law, and it has long since become a thing of the past when the courts give any weight to the presumption of patentability that would naturally arise from the fact of the commissioner of patents having granted a patent upon a device. For the accomplishment of the best results with our patent system, the interpretations and application of the law under which patents are granted should be the same as that under which rights growing out of patents are determined. So that a right granted by the Patent Office would be sustained by the court, and the rulings of the courts would be in conformity with the spirit of the constitution which has originated the whole system.

Under the existing system the examiners in the Patent Office interpret the patent law for themselves, and it has been my experience that few of them agree upon many points. The practical questions which have to be passed upon by the examiners seldom if ever get before the circuit courts, but are decided by the commissioners of pat-

ents, who, it is well known, seldom possess any knowledge of patent law when they enter upon the duties of the office, and seldom occupy the position long enough to be of any practical service to the office after they have learned something of the law by experience. The result is that a majority of the cases passed upon by the commissioners, and which are intended for the guidance of the examiners, are decided at a time when the particular commissioner is almost entirely ignorant of both the law and the practice of the office. It is, therefore, only to be expected that the examiners should form their own notions of the law and pay little regard to either courts or commissioner, and as the examiners are not lawyers and have no knowledge of the patent law, except such as they may gain from the conflicting decisions of the ever changing commissioners, and as they have had no judicial training, it follows as a matter of course that each primary examiner has his own interpretation of the law and his own peculiar notions of how it should be applied to the practical questions that arise in his daily work. The result is that we have as many different patent offices as we have divisions and scarcely any two of them with the same views of the law, but each having the power and exercising it, of issuing patents according to his own individual notion of what the patent should contain and how it should be framed, and these patents thus issued are the title papers upon which the inventors of the country are compelled to base their claim when they come into the courts for the purpose of protecting their property. Is there any wonder that it is difficult to obtain a patent of any value or to sustain and protect it after it is procured? It seems, therefore, to be eminently desirable that the same tribunal (which shall be so framed as to insure its capacity) should have appellate jurisdiction from both the Patent Office and the circuit courts, so that by vesting both jurisdictions in one competent court, the rulings of both branches, the Patent Office and the circuit courts, may be made uniform, and the anomaly removed that now exists of one branch of the government employed in granting patents and another in destroying them. It may be said that such a court exists at this time, but we all know how far removed the Supreme Court of the United States is from the Patent Office, and how little influence it has upon its practice, besides which the existing evils have grown up under the present system, which demonstrates its incapacity to remedy them.

A strong, well-selected court of expert patent lawyers would have many advantages. It would harmonize the Patent Office and the circuit courts. It would crystallize the practice of the Patent Office, so that it would be possible for attorneys to form some conception of what that practice was and be able to advise their clients with safety with reference to their rights. The inventor could have some hope that when he had complied with his part of the government contract by disclosing his secret he would be protected in the exclusive right to use it. Such a court would lift a great burden from the shoulders of the Supreme Court, as but a small proportion of cases decided by it would be appealed to that court, and its rulings being binding upon the circuit courts, would enormously simplify the practice in those courts.

The jurisdiction of such a court should be altogether appellate, and should consist in appeals from the board of examiners-in-chief upon questions of anticipation, patentability and practice, from the examiners of interference, upon questions of priority between applicants for patent upon the same invention, and of appeals from the circuit courts of the United States upon all questions relating to patents that now go to the Supreme Court. It would be proper also to include within the jurisdiction of this court all questions now passed upon by the commissioners of patents, such as trade-marks and labels; copyrights might also be included. With such a court the duties of the commissioner of patents should be purely executive, and the jurisdiction of the Supreme Court of the District of Columbia in matters of appeal from the commissioner should be cut off. The Supreme Court of the District should bear the same relation to this court as the Circuit Court.

Passing from the question of the reorganization of the patent office to specific amendments to the law, the first question that presents itself is the question of limitation to actions.

VI.—LIMITATIONS.

It is pretty well settled by the courts that since the adoption of the Revised Statutes of 1874, there has been no limitation to the right of an owner of a patent to bring suit against an infringer for the recovery of damages for such infringement. Prior to that time, the only limitation that existed was six years after the expiration of the patent, and this seems to be the just rule. Many rules for limitation have been suggested, but it seems to me, in view of the fact which all of us have experienced, that the last few years of a patent are often the only ones during which the inventor realizes anything from his invention, that to cut him off from the recovery of damages from infringers, who may have pirated his invention during a period when he was too poor to stop them, would be unjust in the extreme.

VII.—DAMAGES.

The existing equity rules for the recovery of profits and damages for the infringement of a patent are in very satisfactory shape, but since the decision of the Supreme Court in Root *vs.* The Railroad Co., these rules do not apply to actions brought for the recovery of damages after the expiration of the patent. Such actions must be brought at law, by an action of trespass on the case, and the measure of damages under that form of action is much less liberal than the rule in equity. In an action of trespass on the case, the measure of damages is the actual loss to the plaintiff and not the gain to the defendant; while in equity, the rule allows the recovery of either the loss to the plaintiff or the gain of the infringer, whichever may be the greater, and often the difference is very great. If it is just and right that the owner of a patent should have all the benefits that may or can be derived from the use of his invention, and this is the theory of the law, and in one form of action before the expiration of his patent is allowed to recover these benefits, in the absence of a statute of limitations, why, in justice, should he be deprived of this benefit simply by the expiration of his patent? It would seem as if this evil should be remedied by legislation. It might be done by giving a plaintiff a standing in equity under a bill for an account and discovery, independent of an injunction, or if the patentee were permitted to bring an action of assumpsit for recovery of the benefit that the infringer had derived by the use of his invention, this might be almost as well; but this would require the interposition of a jury, and in complicated patent cases it is difficult to accomplish satisfactory results with a jury. It is almost impossible to make a jury understand mechanical technicalities or for the attorneys to do justice to the case upon oral testimony.

We have at this time a case in point which illustrates this rule. For seven years the owners of certain patents have been in constant litigation seeking to sustain them. We have recently succeeded in getting a decree in their favor, and a month before this decree was rendered the patents expired. The patents have been extensively infringed and cover important inventions. We have now no remedy save to sue at law by an action of trespass on the case. As a matter of fact the owners of the patents have never established a license fee for their use, but if they had, as they might have done, it would not probably have been more than $10 for each machine. Hence, this sum in our action at law would have been the limit of our possible recovery; notwithstanding the fact that the infringer by the use of each machine has saved to himself

not less than $500. Why should the rule of law in a case like this be different from that in a case where a man without my knowledge or against my will carries off my horse and uses him for his own benefit for a certain period, after which I recover him? In such a case I bring a suit and the jury estimates the benefit that the wrong doer derived from the use of my horse and awards me this amount as damages for his wrongful act. Would it be right that this wrong doer should have the power of escaping liability by answering when the jury found that he had made $100 by the use of my horse, that I could not in the same time have made but $10 with it? Would not this be putting a premium upon the wrongful act?

The question is still an open one whether in those states where the common law forms of action have been abolished, an action could be maintained at law for the infringement of a patent, the substantial result of which would be the same as the common law action of assumpsit, although the statute prescribes an action of trespass on the case as the proper action.

VIII.—REISSUES.

Since the decisions of the Supreme Court in Miller *vs.* The Bridgeport Brass Company and the line of cases that have confirmed this doctrine, it may be said that a reissue, in the sense in which that term was formerly employed, is no longer possible. The unfortunate inventor who has employed, in his ignorance, an incompetent solicitor to procure his patent, or who yields to the unnecessary limitations of the office, and whose patent issues to him covering half of his invention, or possibly contains a disclaimer disclaiming the other half, can be said to-day to have no remedy for his misfortune; and if two years have elapsed since he procured his patent, or some enterprising, manufacturer examines his patent and finding that he has not covered the second half of his invention, proceeds to make and sell that half, he is forever barred from going back and claiming it. Some change in the law should surely be made to enable an innocent and meritorious inventor to secure the full benefit of his invention, if this can be done without destroying vested property rights in individuals.

Under the present law, when a patent is surrendered in order to obtain a reissue, all accrued causes of action for past infringement upon the original patent go with it, and no action can be brought for an infringement committed prior to the date of the reissue. There does not appear to be any good reason for the existence of this rule.

At present an application for a reissue must be signed and sworn to by the inventor. This rule puts it into the power of a dishonest person to extract money from the owner of the patent by refusing to sign the reissue papers. The owner of a patent should have the power to deal with his property as he chooses, and as he is considered, when he purchased the patent, to have purchased all that could have been covered by the inventor's original application, if the patent does not do this, he should have the power to reissue his patent upon his own petition, and an oath that he is the sole owner, or if there be several, that they own the whole title.

IX.—REPEAL OF PATENTS.

The statutes of the United States contain no provision which will permit a patent supposed to have been obtained by fraud or mistake to be set aside, nor for any action by the United States against the owner of such a patent to prove the fraud and have the patent declared void. The statute should contain such a provision.

X.—EQUITY PROCEEDINGS FOR SLANDER TO PATENT.

Neither statute nor precedent in this country authorizes an equity proceeding for an injunction to restrain the continuance of slander against a machine or a patent, by one who falsely charges that the machine or the patent is an infringement of another patent owned by him, and threatens suit for such infringement, but neglects to bring such suit, and who thus continues to disturb the business of the party slandered without attempting to execute his threats or to vindicate his claim. Such an injury cannot adequately be remedied by an action at law for damages. What is wanted is an injunction from a court of equity to stop the tongue of the slanderer at once and forever.

XI.—LICENSES.

Licenses should be recorded and subject to the same rules as mortgages of land: the license first recorded should take precedence.

XII.—JOINT OWNERS.

The mutual rights of joint owners of a patent are in a very unsettled state in the present condition of the law, and it would, I think, be much safer to say that joint owners are entirely independent of one another—although there are some cases to the contrary—than to venture any statement with reference to what those mutual rights may be.

It would seem that no good reason could be advanced why joint owners of a patent should not bear the same relation to one another as joint owners of any other property. If two persons own a house jointly, but in definite proportions, and one of those persons rents the house and receives the rent for it, the other can, of course, receive his share of the rent either from the person or from the property. The absence of well-settled rules upon this subject makes it very desirable that they should be established by statute.

XIII.—U. S. PATENT LIMITED BY FOREIGN PATENT.

United States patents should not be limited to expire with the shortest lived foreign patent upon the same invention, for the simple reason that the American inventor who gives his invention as a free gift to the foreigner, gets a patent here for 17 years, while he who seeks to protect himself abroad may limit his United States patent by several years.

XIV.—ASSIGNMENT.

Assignments of patents should stand upon the same footing as conveyances of land: the assignment first recorded should take precedence.

XV.—EXPENSE OF LITIGATION.

Expense of the trial of patent cases might be lessened if the court was authorized, in impanneling a jury as provided by the act of 1875, to impannel a jury of five experts in the subject-matter of the case, pay them a suitable per diem, let them hear the testimony, and advise the court. Cochrane *vs.* Deener, 4 Otto, 784.

XVI.—INTERNATIONAL CONVENTION.

The United States by its adherence to the International Convention pledged itself to adopt legislation as soon as possible to harmonize the existing law of this country with the international law. The practical result that Americans need in relation to foreign patents is a period of say six months after they have secured an allowance of their United States patent to make their applications abroad without affecting the term of their United States patent.

I have thus rapidly touched upon the points in our patent law that need revision, without attempting to formulate specific additions to the statutes. This, I think, can only be done effectually by a commission of expert lawyers, such as is contemplated by the bill that we will introduce into Congress. In order to secure the passage of that bill, we will need the aid of every man who is interested in this subject exerted to the fullest extent; we would most earnestly urge the importance of this effort in its possible effects upon the country, and solicit your assistance in making it successful.

ELECTRIC PUMPING IN COLLIERIES.[1]

Before electricity is adopted by practical mining engineers, they must be convinced that it can compete economically with other modes of transmitting energy—modes which are well known and generally applied.

What percentage of indicated steam power applied to the generating electric machine is given off ultimately as available energy for mechanical work? How does it compare as to cost? Under what circumstances would its application be economical? If leading main questions such as these can be plainly and satisfactorily answered, practical men will not be long in arriving at a favorable opinion and acting upon it.

The application of electricity to underground pumping has enabled the writer to tabulate some particulars which he believes will go a long way toward satisfying inquirers that this is a method of transmitting energy capable of wide and economical adaptation.

Some four years ago (vol. 13, No. 5) Mr. W. B. Brain described to this institute in a short paper a small electric pumping plant at Trafalgar colliery, Forest of Dean, doing the work of about 1½ h. p. This, the writer believes, was the first attempt ever made at pumping in mines by electricity. It has continued working satisfactorily up to the present time. A similar set using about 2½ h. p. has been working in another part of the mine, some 800 yards from surface, for the past one-and-a-half years. Both are doing excellent service removing small quantities of water from remote parts of abandoned workings, which for the safe working of the colliery must be kept free from accumulations of water. It may be well to say that the majority of the collieries in the Forest of Dean have their shafts sunk on the "rise" of the taking, and the coal is won by "dipples," or engine planes, going full dip with the strata. The outcrop is riddled with old abandoned workings. These receive a great quantity of surface water, which finds its way down the slope of the strata to the deeper workings now in operation. The two electric pumps above referred to intercept some of this water on its downward course. The electrical pumping plant which the writer purposes describing in this paper has been put in to deal with the main come of water in the deep workings of the Trafalgar colliery. The pump and motor are placed a distance of about 1,650 yards from the bottom of the shafts, and the water has to be forced by this pump a vertical height of 300 feet to the pit bottom. This water had, previous to May last, been coped with by one of Hathorn Davey's water-power pumps, working in conjunction with a 7-inch double plunger Manchester Pearn pump with 10-inch steam cylinders and 14-inch stroke, the steam being obtained from the tubular boilers fixed underground.

The present pump—a double 9-inch plunger with 10-inch stroke—has been specially designed by the Lilleshall Iron Co., limited, from sketches furnished by the writer, and is fitted with spur gearing running six to one. It is driven by a leather link belt, running off a 5-feet 4-inch pulley keyed on the same shaft as the spur pinion to a 14-inch pulley on motor shaft. Thus, when the motor is running at about 650 revolutions per minute, the pump is making 25 revolutions. The motor, supplied by Elwell-Parker, limited, of Wolverhampton, is described as one of their 12-inch machines—maximum speed about 650 revolutions per minute, output about 13,000 watts. The electric current is conveyed to it by a copper cable 2,000 yards long, 19.16 wires, wrapped in compounded tape, which was supplied by the India-rubber, Gutta-percha and Telegraph Works Co., limited, Silvertown. This is enclosed in wooden boxes in the pit shaft only. It is supported upon earthenware insulators placed at intervals of about 10 yards along the side of the underground roads. The return cable is an old iron pit rope about four inches in circumference, stapled to the road posts. The generator, placed on surface near the top of the shaft, is another of Elwell-Parker's 12-inch machines. Its maximum speed is about 950, and output 17,000 watts. A belt communicates the power from a 12-inch pulley on the generator to a 5 feet 11 inch pulley attached to the crank shaft of an engine. The steam engine has a single 16-inch cylinder with 12-inch stroke, and works with about 35 lbs. steam pressure. It is an old marine engine, picked up some time since at an auction sale, and is not what one would purchase new for the work. It indicated, running empty, a loss of 5 h. p., the valves and piston both being the worse for wear. In the same engine house is another engine which supplies the power for the two small electric pumps previously referred to. The steam for both is obtained from the range of colliery boilers near. A small insulated copper wire connected to a battery of eight No. 3 Leclanché cells connects the engine house with the pump house underground, and through this is registered upon a belt in the former each stroke of the pump. It is also used as a telephone line, so that a conversation can at any time be carried on between the engine man on surface and the man in charge of the pump underground. The two smaller pumps are locked up, with no one in charge, only being visited occasionally; but with this larger one some one is thought necessary, although there is rarely anything more to be done than oil the machinery, adjust the machine brushes, and turn on the electricity. Near the engine the necessary electrical instruments—a voltmeter and an ammeter—are placed, by which the engine man knows the machines and cables are working properly. A magnetic cut-out is also placed in the main circuit, so that should the current, through any unforeseen cause increase, it automatically breaks the circuit, thus preventing the flow of electricity through the cables. The maximum speed at which the pump has been driven is 25 strokes (114 gallons) per minute. The observations taken at the time were:

Indicated h. p. of steam engine	29.49
Speed of generator	900.00
Volts at terminals of generator	320.00
Amperes ditto	43.00
Speed of motor	650.00
Volts at terminals of motor	260.00
Amperes ditto	43.00
Actual h. p. of water lifted	10.36

The first diagram exhibited is prepared from the above figures, and shows the total loss of power (19.13 h. p.) to be apportioned thus:

Loss in engine	6.49 h. p.	or 22 per cent.
Loss in generator	4.56 "	" 16 "
Loss in line	3.45 "	" 11 "
Loss in motor	3.00 "	" 10 "
Loss in pump	1.63 "	" 6 "
	19.13 h. p.	or 65 per cent.

The actual proportion of power given off by steam engine used to lift water is, therefore, 35 per cent. A second diagram shows the percentage of useful effect extracted from the power received at each stage, together with the percentage of loss, thus—horse-power indicated by steam engine, 29.49.

	H. P.		Per cent.	Useful effect. Per cent.
Received by generator	23.00	Loss in steam engine	22	78
" " cables	18.44	" " generators	20	80
" " motor	14.99	" " cables	20	80
" " pump	11.99	" " motor	20	80
" " water	10.36	" " pump	14	86

A third diagram shows the loss between the power given off at the belt of the steam engine and the actual work done, thus—horse-power given off to generator, 23.00.

	H. P.	Per cent.
Loss in generator	4.56	or 20
" cables	3.45	" 15
" motor	3.00	" 13
" pump	1.63	" 7

1. Read by Frank Brain, before the South Wales Society of Engineers, Cardiff, Nov. 24, 1887.

The proportion of power given off by belt used to lift water is, therefore, 45 per cent. As to cost, the writer has been to considerable pains to verify the following figures, knowing that with business men this is the crucial test. The following is a summary of the first cost of the plant:

Two electric machines	£310
Insulated copper lead	138
Return wire—iron rope	25
Signal wire	10
Insulators	6
Steam engine (estimate)	140
Fixing and sundries	15
	£644

The pump (£130) and pipes are not added to the above, seeing that this item of cost would of necessity be part of any set of plant, and it would therefore be an item of cost common to all systems.

Detailed cost of pumping 114 gallons per minute with above machinery, through 1,300 yards 7-inch pipes—main rising 300 feet—one week's pumping, 22 hours per day:

	£	s.	d.
Engineers (half time)	1	8	0
Man underground (full time)	2	9	0
Small coal consumed, say 36 tons at 1s.	1	16	0
Oil, waste and sundries	0	7	0
Say 15 per cent	1	17	0
	£7	17	0

Cost per horse-power on water raised, .02 of a penny; cost per 1,000 gallons of water raised, 1.80 pence.

The come of water in the deep workings of the colliery has been much below the average during the past dry autumn. The pump has therefore been usually worked at about 64 gallons per minute. The results, of course, not being so good, are as follows: Proportion of power generated used to lift water, 32 per cent.; cost per horse-power in water raised, 0.3 of a penny; cost per 1,000 gallons of water raised, 3 pence.

When opportunity offers, and the hold of water is pumped out, this plant is utilized to assist in maintaining the ventilation. Some 1,200 yards underground a small fan, passing some 10,000 cubic feet of air per minute, is placed in a return air way. A branch connection is made from the main cable to a dynamo which drives the fan by belt connection. The cost of maintaining the present plant, compared with that it has supplanted, shows an economy of about £470 per annum. This the writer does not, however, rely upon as a fair comparison of cost, seeing that the former plant had to be worked under most disadvantageous circumstances.

The whole of this plant was supplied by the various makers to specification, and was put in by the colliery mechanics without any outside assistance. It commenced working without a single hitch, and has worked continuously since the end of May last with but one accident. This, strictly speaking, cannot be spoken of as an accident. A couple of weeks ago we found much more current was being taken to do the ordinary work than usual, and on examination traced the cause to the cable in the pit shaft.

Here, as already explained, the cables which are not highly insulated are carried in wooden troughs. The late continuous heavy rains had very much increased the feeders of water in the shaft, and this water, finding its way into the boxes saturated the cable, causing a great escape of electricity. A lead-covered cable was substituted for the ordinary one, and the difficulty was thus completely overcome.

The cable was a matter of some anxiety when the plant was being provided, as the writer feared that falls which cannot be prevented on underground roads would be constantly damaging it and causing delays.

In practice this has never been yet found to occur. With the one line indestructible (as the iron pit rope practically is), the other, should it be damaged, can quickly and easily be repaired or replaced with new, so that this, one of the most formidable of the anticipated difficulties, has proved quite illusory. The plan which has been adopted of supporting the cable upon earthenware insulators has proved a good one, more perfect insulation, a very important factor, being obtained. The repairs necessary to the side timber of the roads along which the cables are suspended is also facilitated.

The commutators are the principal electrical wearing parts, and with care these will run a considerable time. In this instance, after five months' work, the wear shown is only about one-sixteenth of an inch, although there is an inch thickness of copper to be worn away before it is necessary to have a new one. With a spare armature kept in hand, which costs about one-third the price of a machine, no accident can happen which the colliery mechanics cannot repair, and that with little delay, everything being simple in construction and easily to be got at.

It is an advantage which colliery managers will appreciate to concentrate work and have it under personal supervision. Given sufficient engine power, any reasonable number of generators can be driven in one engine house on surface, delivering power to distant places underground at various points of the compass. These dynamos would require but one man to attend to them, and the work done could with ease be supervised. The steam, too, can be generated at least possible cost under such circumstances, and with the work divided between two or three engines, a breakdown with either, should it occur, need not cause any delay. It is especially noticeable that this plant can be put down economically and with great despatch. With pipes carrying steam, compressed air, or water, it is often necessary to place them in ditches specially made at considerable expense along the sides of the underground roads, so as to protect them from injury and keep them out of the way.

The outlay in pipes is also great, more especially when the route is devious, and if the roads are at all given to "puck," these are constantly being broken.

With electric cables none of these difficulties occur. No matter how intricate the route may be, a thousand or two thousand yards can be put to work in as many hours as it would require weeks to put in pipes. Given a pump with the necessary suction and delivery pipes fixed a mile underground, with steam-power available on surface, and it would be practicable to have that pump in work in less than a week, an impossibility with any other method.

A few brief extracts from papers already published, comparing the cost of electricity with the power derived from steam, compressed air or hydraulics, may be interesting.

The following is given by Professor Schulz ("Proc. Inst. Civil Engineers," vol. 78, p. 67, and "Transac. N. of Eng. Institute of Engineers," vol. 34, p. 5). Total cost of underground haulage by locomotive:

	Per ton in pence.
Steam engine	1.0
Electric engine	1.54
Compressed air engine	2.06

Total cost of various systems of underground haulage:

	Per ton in pence.
Endless chain	0.98
Rope and counter rope	1.26
Electric locomotive	1.54
Rope and tail rope	1.89
Endless rope	2.83

A comparison between electric transmission and mechanical methods was published in Berlin, in 1883, by A. Beringer, and awarded a prize by the Electrotechnical Society there.

A *resumé* of it appears in the "Revue Universelle des Mines" (ser 2 tome 15, p. 522). The following brief extract may be of interest:

Comparison of cost on 10 effective horse-power hours transmitted 1,093 yards :

By cables	1.77d.	per effective horse-power per hour.
" electricity	2.21d.	" " " "
" hydraulics	2.90d.	" " " "
" compressed air	2.98d.	" " " "

Comparison of cost on 50 effective horse-power hours transmitted same distance :

By cables	1.85d.	per effective horse-power per hour.
" hydraulics	1.87d.	" " " "
" electricity	2.07d.	" " " "
" compressed air	2.27d.	" " " "

Comparison of cost on 10 effective horse-power hours transmitted 5,645 yards :

By electricity	2.64d.	per effective horse-power per hour.
" compressed air	4.66d.	" " " "
" cables	4.69d.	" " " "
" hydraulics	5.29d.	" " " "

Comparison of cost on 50 effective horse-power per hour transmitted 5,465 yards :

By electricity	2.37d.	per effective horse-power per hour.
" cables	2.65d.	" " " "
" compressed air	2.99d.	" " " "
" hydraulics	3.02d.	" " " "

Steam was the prime motor used in each instance. From the above figures it is to be inferred that for distances of about 1,000 yards cable transmission costs least, but that in longer distances electricity takes the lead and maintains it against all other systems. The cost per effective horse-power per hour of the electrical pumping plant herein described is found by the figures as to cost, already given, to be 1.18d. It is obvious that a future is before electricity in the transmission of power. For coal cutting, it affords a ready means of distributing power ; for hauling engines, which can either be stationary or run to various parts of the colliery on prepared tracks—as well as in pumping—this new motive power must take a place, and that no despicable one, in the future of colliery work.

APPLICATION OF ELECTRICITY TO LOCKS.

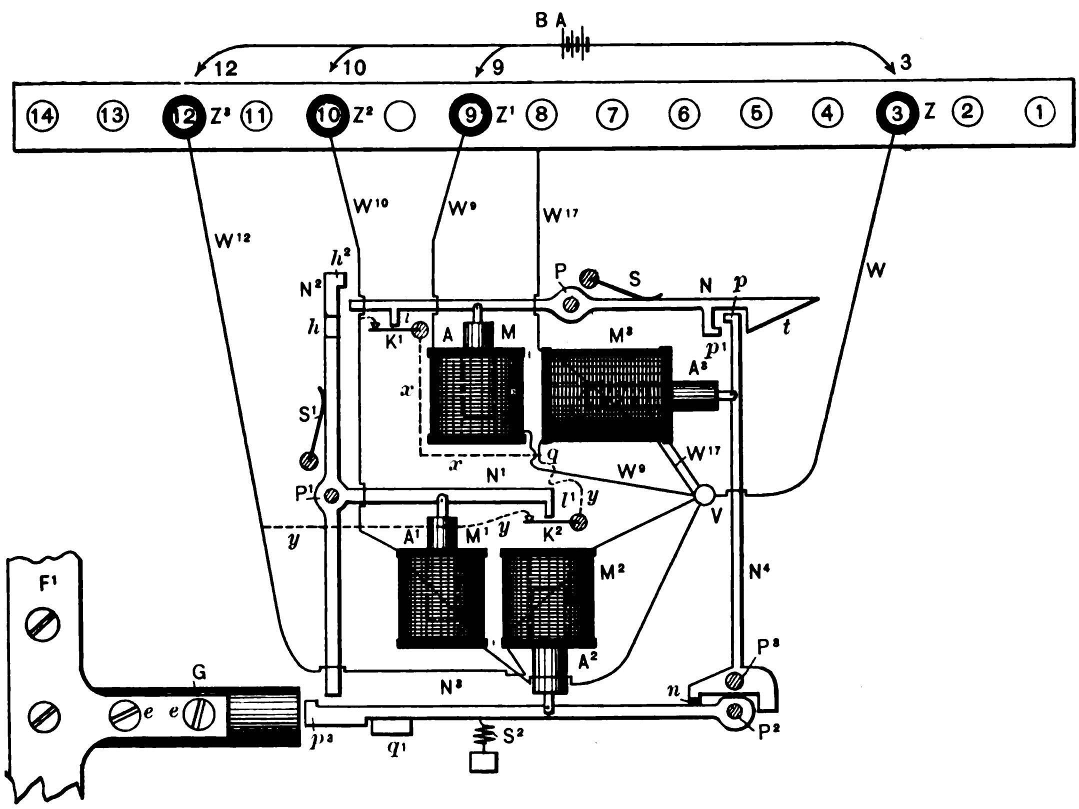
We give below a description of one of a series of electrical combination locks recently patented to Mr. C. J. Kintner, late Principal Examiner in the U. S. Patent Office.

The inventions covered by Mr. Kintner's patents are novel and very interesting, and to say the least, they exhibit a new extension of electric art in usefulness to the world by affording security to valuables and foiling the attempts of burglars, adding one more to the rapidly multiplying means of safety and convenience in the world of business.

It is claimed for these locks that they are decidedly more simple in their construction and mode of operation, and, therefore cheaper and more secure than well-known forms of mechanical combination locks.

The sketch shows the locking parts in the interior of a safe, the battery, or preferably a magneto generator, being located on the outside.

A series of insulated wires, say 50 in number (in the



sketch shown as 14), lead from the exterior of the safe to a switch-board within, all of these wires being electrically connected to such switch-board, as shown, save in this instance, numbers 3, 9, 10 and 12, which are insulated therefrom by washers and have continuing conductors W, W^9, W^{10}, W^{12}, and W^{17}, all leading to a common binding post V, the wires, W^9, W^{10}, and W^{12}, being connected respectively through the electro magnets or solenoids M, M', M^2, while the separate conductor W^{17} runs from the switch-board to and through a safety magnet M^3 to the same binding post V. The wire W answers as a return wire for all four of the wires W^9, W^{10}, W^{12}, and W^{17}.

X and Y are shunts normally closed about the magnets M' and M^2 by the springs K' and K^2 lying in the path of the lugs l and l' on the armature levers N and N'; S S' S^2 are retractile springs for holding all of the levers in their locked positions.

N^4 is a safety lever pivoted at P^3 and having a soft rubber spring, n, on its short arm bearing against the locking lever N^3, so that when said lever is drawn up by the action of the solenoid M^3 it will tend to hold locking lever N^3 in

its locked position and at the same time cause its hooked end, p, to engage the hook p' on lever N.

The shunts X and Y unite at q and pass thence in a direction about the core of solenoid M^3 the reverse to that of the main coil joined to W^{17}, so that if the circuit is closed at 10 or 12 through any other number outside the safe this safety magnet will be actuated and permit the operation of the lock. The outer ends of the insulated wires lie beneath two horizontal metal rods (not shown), one of which is attached to the plus pole of the battery and the other to its minus pole. On one of these bars is a sliding contact maker and on the other are three similar to the first, all of which are adapted to connect the contacts lying under them directly to the battery as they are slid along across the outer face of the safe door.

The operation is as follows: The combination numbers are in this instance, 3, 9, 10 and 12, being chosen from a series of 14 numbers; while the other 10 numbers are connected to the safety circuit by direct contact with the switch-board and wire W^{17}.

To open the lock, place the contact maker of, say, the lower horizontal rod attached to the face of the safe upon the exterior contact point 3; next place any one of the three contact makers of the upper horizontal rod on point 9. The battery circuit will then be closed from the copper or plus pole as shown by the arrow at 9, to and through insulated wire number 9 to the inside of the safe, and thence by wire, W^9, magnet or solenoid M to post V, by wire, W, to point 3, and finally to the exterior of the safe and minus pole of the battery, as shown by the arrow.

This energizes solenoid M, and causes its core to turn the lever M about its pivot P against the action of spring S, and to bring the lug l into mechanical contact with spring K′, thus breaking the shunt X to the second magnet, M′, of the combination, and at the same time drawing the hook p' out of the path of the hook p on the safety lever N^4.

Now cause the second contact maker of the upper horizontal contact rod to be placed upon the point 10, the second number of the combination, and the battery will be closed in multiple arc by the path already described, and a second path from point 10 by wire 10 through the door to inner point 10, and wire W^{16} to and through magnet or solenoid M′, thence to common point V and out by wire W as before. Magnet or solenoid M′ is energized, causing lever N′ N^2 to tilt about its pivot p', so as to carry the lower end to the left out of the path of the locking lever N^3, and at the same time cause the upper end N^2 to mechanically lock the lever N which now extends into the opening h.

This same action breaks the shunt Y of the last locking magnet M^2 at the spring l^2 by means of lug l^1 on lever N′.

The first circuit may now be broken if desired. The last circuit is now closed by placing the last contact maker on the upper horizontal contact rod in contact with the point 12 beneath it, when the circuit is again closed through the additional multiple arc branch W^{12}, magnet M^2 and common return wire W, thus causing the last or locking lever N^3 to be drawn up against the action of spring S^2, and out of the path of the lug G on the bolt frame F′.

The bolts may now be drawn by turning the bolt handle (not shown) in the usual manner, and this lug G will be forced to the right under the raised end of the locking lever N^3. The circuit may now be broken at point 3 and the combination contact maker slid along to any desired position on the horizontal rods which support them. These rods are not shown in the sketch. On returning the bolts into locking position, the locking lever N^3 and the levers N^2 N, all fall into locking position under stress of their springs S S′ S^2.

If the circuits be closed in any other order than that indicated, the safety magnet M^3, will be actuated and cause its lever N^4 to firmly hold the last locking lever in position, and at the same time lock the lever N against action.

The arrangement is such that each armature lever locks its companion, and they all in turn lock the bolts.

In the simplest form of lock made by Mr. Kintner, the shunts are omitted, thus avoiding liability of derangement of contacts on the inside of the safe. He is building a safe with such a lock, and will place it on exhibition within a month.

It will be seen that this lock simplifies the operation of entering safes very materially, and it is found that four seconds at the utmost will suffice to draw the bolts.

ELECTROLYSIS OF IRON SALTS.

BY ALEXANDER WATT.

THE electro-deposition of iron, although it has met with some few applications—but more especially in the so-called "steel-facing" of engraved copper plates and printers' type—has not yet received so much attention in this country as it deserves. Indeed, iron-plating—which is a better term than *ironing*, which would smack rather of the laundry—and iron electrotyping may be said to be as yet but in their infancy, so far as development is concerned. There can be no doubt that if iron electrotypes could be as freely obtained as we produce those of copper, a very important field of enterprise would be opened up for those who follow the art of electro-deposition. Before this desirable object can be attained the study of various solutions of iron salts, with and without the addition of other substances, must receive further consideration. With a view to aid those who are interested in the electro-deposition of iron generally, I purpose giving the results of a series of experiments which I have made from time to time in the deposition of iron, from which it will be seen that while there are many iron salts from which the metal may be deposited readily and of good quality, other salts are totally unfit and valueless for the purpose. When desirous of taking up any new branch of electro-deposition, it is advantageous to the student, not only to know the nature and behavior of those materials which are most suitable for his purpose in a practical sense, but he should also have some knowledge of the short-comings of other salts of the same metal in case at any time he might be tempted to experiment in the same direction himself.

In depositing iron from its various solutions many difficulties have presented themselves which ingenuity has to some extent overcome. The rapid oxidation of the iron salt of the surface of the electrolyte, and the blackening of the deposit at the corners and edges of the plate have, amongst other sources of annoyance, been the most troublesome causes of failure. Again, with some solutions it has been found that the anode did not dissolve with sufficient readiness to keep the bath up to its normal strength. These faults have, however, been to some extent overcome, and so far as light deposits are concerned—such as in the facing of engraved copper plates—the deposition of iron presents but little difficulty. The production of iron electrotypes, however, has yet to receive further development before the process becomes a practical art of general application.

In describing the various solutions of iron which I have electrolyzed, with a view to determine what character of deposit they were capable of yielding, it may be well that I should also refer, in passing, to those solutions which have hitherto been employed or recommended for the deposition of this metal. In making up baths from any of the well-known solutions, I would recommend the operator—regardless of prescribed formulæ—always to make his solution a trifle too weak rather than adopt the other extreme, since weaker solutions will often give far better results than stronger ones, and the gradual strengthening of the bath can readily be resorted to if occasion requires it. Too strong a solution of any iron salt is pretty sure to give an indifferent deposit and cause disappointment, whereas with a weaker solution—if it be a good one in other respects—the deposition is merely slow, a fault easily remedied by the *gradual* addition of more iron salt. The alterations of the strength of the bath should never be made, however, until the operator has satisfied himself that the current is adequate. When practical, the solution (proto-sulphate, for example) should be put into such a condition that it will work well with a surface of anode about equal to that of the cathode, when working at the ordinary temperature. With some solutions, however, this would not be practical, as in cases where other salts besides those of iron are used for preparing the bath, which have little or no solvent action upon the iron anode.

Proto-Sulphate of Iron.—Various proportions of this salt to the gallon of water have been employed in making up baths for depositing iron, but I found the following give exceedingly good results with a somewhat weak current: About half an ounce of good sulphate of iron was dissolved in a pint of cold water. One small Daniell cell was first tried, with electrodes of about equal surface, but the deposit was of rather dark color. A few drops of sulphuric acid were then dropped into the bath, and an extra cell connected, when a considerable improvement in the color was

manifest; a third cell was now added—the whole being in series—when the deposit became exceedingly white and bright, which character it maintained. At the end of about two hours the plate (sheet copper) was withdrawn, when its brilliant appearance resembled that of copper which has been dipped in mercury. There was considerable evolution of hydrogen. On examining the anode (a plate of wrought iron), it was found to have been very equally and very freely acted upon, and presented a very clean surface.

Proto-Chloride of Iron.—A moderately strong solution of this salt did not yield a good deposit; neither was the color of the film improved by diluting the solution. In all conditions of the liquid the deposited metal had a tendency to blacken after a short immersion of the negative plate. The best results were obtained with two Daniell cells.

Ammonio-Sulphate of Iron.—A solution of this salt, used with a rather weak current, is undoubtedly one of the best for the deposition of iron. The solution is greatly improved, however, by the addition of a moderate quantity of acetic acid. I found the following proportions yield a very white deposit of iron with two small Daniell cells:—Ammonio-sulphate of iron 1¼ oz., water one pint. The deposit, though not so bright as that from the proto-sulphate before referred to, was very white and uniform in character; there was no blackening of the film at the corners of the plate, and deposition took place very freely.

Tartrate of Iron.—A solution of this salt was prepared by dissolving recently precipitated hydrated sesquioxide of iron in a strong and hot solution of crystallized tartaric acid. With two Daniell cells little or no deposit took place. With five cells the film was white at the lower part of the plate, but the remaining surface was of a dark color. The solution is a bad conductor, and not suitable for any practical purpose.

Phosphate of Iron.—Recently precipitated carbonate of iron was dissolved in a strong and hot solution of phosphoric acid. Five cells were used, when a white deposit of iron was obtained upon a copper plate almost immediately. The coating soon became dull, however; and after about half an hour or so the liquid became decomposed, a white precipitate being formed, which settled upon both electrodes and floated about in the liquid. The white salt thus formed was doubtless the proto-phosphate of iron.

Salicylate of Iron.—A solution of this salt was prepared by dissolving recently precipitated carbonate of iron in a hot solution of salicylic acid, when a deep red liquid resulted, which yielded a tolerably prompt deposit of iron of a darkish color, but fairly adherent, upon a copper surface. Five cells were necessary to obtain a successful deposit.

Potassio-Tartrate of Iron.—A solution of this salt yielded a tardy but bright deposit of iron, with five Daniell cells. The solution was not a good conductor.

Sulphate of Iron (*Klein's method*).—A solution of sulphate of iron is precipitated by means of carbonate of ammonia; the precipitate is then well washed and afterwards dissolved in sulphuric acid, care being taken to avoid excess of acid. The solution is used in as concentrated a state as possible. It is stated that good reguline metal may be obtained from this solution by means of a current from four weak Meidinger cells, with an iron anode and cathode of copper. In working this solution it is important to prevent it from becoming acid, for which purpose an anode eight times larger than the cathode, or receiving plate, must be used, and a plate of copper or platinum attached to it, so that the two form a voltaic couple in the liquid, and thus cause the iron to dissolve when the current is not passing.

Perchloride of Iron.—A solution of this salt does not yield a deposit of iron. In electrolyzing a solution of the perchloride, very carefully prepared, a white deposit was at first obtained, which, upon examination, gave a trace of iron, but a greater portion of the film was insoluble either in sulphuric or hydrochloric acid. The deposit was probably due to some metallic impurity of the peroxide (rouge) employed, but this I have not yet determined.

Persulphate of Iron.—This salt also yields no deposit of iron by electrolysis. A copper plate became coated with a dark-colored film, insoluble in either sulphuric or hydrochloric acid, and was probable due, as in the former case, to some metallic impurity of the hydrated sesquioxide of iron employed—though how such a foreign metal could find its way into the precipitated hydrate is a mystery, since it was prepared from an apparently pure sample of jewelers' rouge dissolved in hydrochloric acid and precipitated by ammonia.—*The Electrician* (London).

(*To be continued.*)

THE GENERAL THEORY OF DYNAMO MACHINES.[1]

BY EDWARD HOPKINSON, D.SC.

USING the term "dynamo" in the widest possible sense, including under it all machines for the conversion of mechanical forms of energy into electro-magnetic, and electro-magnetic into mechanical, there are certain characteristics common and essential to all types of such machines, whether they be known as magneto machines, alternate current machines, or continuous current machines, either compound, shunt, or series wound, and of the drum, ring, or disc type. It is therefore possible, up to a certain point, to construct a theory of dynamo machines which is perfectly general in its application. The object of the present paper is to trace briefly the outlines of such a theory, and to indicate how the consideration of specific types of machines can be developed therefrom, and in what direction research is required to elucidate some points still obscure. A dynamo consists essentially of two closed circuits or "tubes," in both of which there is a displacement of the nature of a flux dependent upon the relative motion of the two circuits. We may call one of these the "magnetic circuit" and the other the "electric circuit." Either or both of these may be in motion; but as we are concerned only with the relative motion of the two, we may for convenience (as, in fact, is usually the case) regard the magnetic circuit as fixed, or displaced only by the reaction of the electric circuit upon it, and consider the latter only as moving under external forces, whether electric or mechanical. The flux along the magnetic circuit is called the "magnetic induction," which is a vector or directed quantity, requiring for its definition reference to co-ordinate axes. It is subject to the fundamental condition known as the "solenoidal condition," or "equation of continuity," which may be expressed in words "that the flux across all sections of the tube is the same," or otherwise "the induction through any surface bounded by a closed curve depends only on the form and position of the closed curve, and not on that of the surface itself." The flux along the second circuit is called the "electric current," and is also a vector quantity, subject to the solenoidal condition. Neither circuit is necessarily bound by the limits of the machine, and both may be, and generally are, subdivided. Both these fluxes are produced by corresponding forces, called respectively "magnetic force" and "electromotive force," which likewise are vector quantities, but are defined by reference to a line instead of by an area, as is the case with the fluxes. (Maxwell. "Treatise on Electricity and Magnetism," vol. i., page 10.) The solenoidal condition for magnetic induction is a direct deduction from Coulomb's original experiment, verified by all subsequent observations in magnetism. We now require to know the relation between each force and its corresponding flux. Let us first inquire into the relation between the magnetic induction (B) and the magnetic force (H). Such a relation may be expressed by the general equation

$$B = f^{-1} (H).$$

The form of the function depends upon the medium in which the tube is drawn, and also upon the physical conditions of the medium. For air and all other gases, and generally for all substances classed as "non-magnetic," it is a linear function possessing one co-efficient or constant only. For such substances the equation may be written

$$B = \mu H.$$

Since the numerical definition of H is at our disposal, we may so define H that μ is unity for all the substances above referred to, and write

$$B = H.$$

For iron, and generally for all magnetic substances, H is not a linear function of B, and its expression will involve several constants depending upon the medium, and such physical conditions as temperature and strain, and its previous history. The determination of the form of the function for iron in particular has been the subject of a great number of experiments, but no general expression has yet been discovered, and it has usually been found most convenient to record the experimental results in the form of a curve referred to rectangular axes, in which the ordinates represent magnetic induction and the abscissæ magnetic force. Such curves have been fully investigated for iron of various composition, and under varying physical conditions, among others particularly by G. Wiedemann (Die Lehre vom Galvanismus, vol. ii., page 340 and sequor), Rowland (*Phil. Mag.*, August, 1873), Carl Barus and Vincent Strouhal (Bulletin of the United States Geological Survey, No. 14, 1885), J. Hopkinson (Philos. Trans. of R. S., part ii., 1885), J. A. Ewing (Philos. Trans. R. S., part ii., 1885, and part ii., 1886, and Proc. of R. S., vol. xlii., page 200, 1887). By reference to these memoirs it is now possible to construct the curve with fair accuracy for iron of any known composition. For convenience we may express the curve by the equation

$$B = \mu H.$$

μ is then the tangent of the angle which the tangent to the curve makes with the axis of x. It has received various names; by Sir William Thomson, "permeability" (Reprint of Papers on Electricity and Magnetism, vol. ii., page 54); by Maxwell, "coefficient of magnetic induction" (Treatise on Electricity and Magnetism, vol. ii., page 54); and again, "magnetic inductive capacity" (vol. ii., page 243).

Secondly, we require to know the relation between the E. M. F. and current. This is well known to be expressed by a linear rela-

1. Read before the British Association for the Advancement of Science (Section A.—Mathematical and Physical Science), Manchester, September 6, 1887.

tion, known as Ohm's law, involving one constant coefficient only, universally designated the "resistance."

$$E = R\,C.$$

E being the E. M. F., and C the current. As far as all experimental evidence goes, R and the reciprocal of μ possess the same two characteristics, viz., that for any given substances in any defined physical condition they are proportional to the length of tube considered, and inversely proportional to its cross-section; μ may therefore without impropriety be called the reciprocal of the "magnetic resistance," but as expressing this analogy only. It must be distinctly remembered that for magnetic substances there is no such relation as Ohm's law.

Having now defined the relation between the fluxes and their corresponding forces, it remains to consider the relation between the fluxes themselves, dependent upon the relative motion of their circuits. This may be expressed in various ways, all of which are the expressions of Faraday's well-known law: (1) The line integral of the E. M. F. round the electric circuit is the rate of decrease of the surface integral of magnetic induction through any area bounded by the circuit; or (2) the time integral of the total E. M. F. round the electric circuit together with the surface integral of the induction through the circuit is a constant quantity. Again, since the surface integral of any vector over any surface which satisfies the solenoidal condition can be expressed by a line integral round any closed curve bounding the surface, a new vector may be introduced called the "vector potential" of magnetic induction, which is such that its line integral round any circuit is equal to the surface integral of induction over any surface bounded by the circuit. Also the time integral of the E. M. F. in any circuit is the electro-magnetic momentum. Hence Faraday's law may be expressed. (3) The electro-magnetic momentum of a circuit is the line integral of the vector potential round the circuit (Maxwell, vol. ii., pp. 28 and 234).

Excluding for the moment the consideration of magneto machines with permanent magnets, and of machines in which iron plays no part whatever, we may more particularly consider that class of dynamos in which the magnetic field is produced by the use of iron excited by a current; and we then require to know the relation between the current and the induction in the magnetic field produced by the current. Faraday showed that the magnetic field in the neighborhood of an electric current is the same as that of a magnetic shell bounded by the circuit of the current, and has therefore a similar magnetic potential. This is expressed by saying (4) that the line integral of magnetic force round any closed curve is zero, provided the closed curve does not surround the electric current, and if the current passes through the closed curve, then the line integral is proportional to the number of times it passes through, and is equal to $4\,\pi\,n\,c$, where c is the current and n the number of times it passes through the closed curve.

If we take the magnetic units as fundamental, the propositions (1) and (4) define the units of E. M. F. and current, On the other hand, if we start with the arbitrary units of E. M. F. and current, based on quite other considerations, the propositions define the units of magnetic induction and magnetic force in terms of these.

We have now the materials for a complete investigation of a dynamo of any given configuration and constructed of iron, whose magnetic qualities are known. It is required to determine the E. M. F. and current in the electric circuit, as its configuration relative to the magnetic circuit is changed by the application of external forces, and as the magnetic forces in the magnetic circuit are changed either by external electro-magnetic forces or electro-magnetic forces derived from the current circulating in the electric circuit. The magnetic circuit consists in general of four parts: (1) The magnet limb, which is surrounded by coils of wire, through which the exciting current is passed, which may be derived either from external sources or may be part of the electric circuit of the machine. (2) The field pieces, or the extended polar extensions of the magnet limb, embracing the armature. (3) The air space, being the necessary interval between the iron of the pole-pieces and the iron of the armature, or in cases where the armature contains no iron, the interval between the opposed pole-pieces. This interval may be an entirely free air space or partially occupied with other non-magnetic matter, according to the particular type of machine. (4) The armature, or that part of the machine carrying that portion of the electric circuit which is subject to displacement under external forces. There may be other subsidiary portions of the machine, *e. g.*, the magnet limb may be divided into one or more portions connected by yokes, but as these may be treated in exactly the same way as the pole-pieces, they do not require special consideration. Again, the magnet limb may be divided so as to form several magnetic circuits; each of which may be considered independently. In alternate current such sub-division is universal, and is not infrequent in continuous current machines.

The magnetic circuit is thus subject to magnetic forces due to the current in the armature and the current round the magnet limb. We must therefore, in the general case, take these as two independent variables, which we may denote by C and c. Now, it may be assumed with sufficient accuracy that in the magnet limb the boundaries of the tube of magnetic induction are coincident with the boundaries of the iron, and the cross-section of the tube the same as the cross-section of the iron. Outside the limb a portion of the lines of force will complete a magnetic circuit through external space, and will not enter the pole-pieces. The extent of this leakage or induction, from which no useful effect is obtained, depends upon the configuration of the machine and the degree of saturation of the iron, and could be calculated therefrom; but as it can be experimentally determined for any machine with great ease, it is unnecessary to consider it further, and we may regard the total induction in the magnet limb as greater than the induction in the pole-pieces in a constant ratio, which we will denote by ν_1. It is usual to construct the pole-pieces of large section compared with the magnet limb, and hence the section of the pole-pieces may again be taken as the section of the tube of induction; but as the lines of force leave the pole-pieces to cross the air space, we cannot ascribe any boundary to the tube, but in every machine a portion only can pass through the armature, and part must pass from one pole-piece to the other by lines external to the armature. Moreover, the relation between the two parts will not be a constant one, unless the magnetic forces in the armature are constant, which can never be the case. It is therefore necessary to consider the tube of induction, which crosses the air space and enters the armature, as a variable portion of the whole tube, the variation depending upon the magnetic forces in the armature. We may denote the ratio of the induction through the pole-pieces to the induction through the armature by ν_2. Knowing now the components of the magnet circuit we can determine the magnetic forces in the several parts, and hence obtain the induction in the tube. Let A_1 be the cross section of the magnet limb, l_1 its length; A_2 the cross-section of the pole-pieces, l_2 the mean length of the tube therein; A_3 the cross-section of the air space, comprising all the space through which the lines entering the armature pass, l_3 its length; A_4 the cross-section of the iron of the armature (if it contains iron), and l_4 the mean length of the tube of force therein. Then the line integral of magnetic force taken round the circuit is:—

$$\frac{1}{\mu_1} l_1 \frac{\nu_1 \nu_2 I}{A_1} + \frac{1}{\mu_2} l_2 \frac{\nu_2}{A_2} - \left(\frac{1\ l_3}{\mu_3 A_3} + \frac{1\ l_4}{\mu_4 A_4} \right) I$$

the μ's being the coefficients of magnetic induction for the several portions of the circuit. For air the coefficient is unity, hence $\mu_3 - 1$. I is the total induction in the armature, which is assumed to be uniformly distributed over the tube. The integration has extended along the tube only which passes through the armature, and hence the forces along the portions of the whole tube which pass outside the machine do not appear. Now, the magnetic circuit is cut by the current in the magnet coils and the current in the armature. Let n_1 be the number of times it is cut by the former, n_2 by the latter. Then

$$\frac{1}{\mu_1} l_1 \frac{\nu_1 \nu_2 I}{A_1} + \frac{1}{\mu_2} l_2 \frac{\nu_2 I}{A_2} + \left(\frac{l_3}{A_3} + \frac{1}{\mu_4} \frac{l_4}{A_4} \right) I - 4\,\pi\,(n_1\,c + n_2\,C)$$

It must be noted that the direction in which the circuit is cut by c and C is in both cases taken to be positive. Referring to three rectangular axes and measuring the induction along the axis of z, the current round the magnets along the axis of x, and that in the armature along the axis of y, the above equation may be written

$$l_1 f_1 \left(\frac{\nu_1 \nu_2 z}{A_1} \right) + l_2 f_2 \left(\frac{\nu_2 z}{A_2} \right) + l_3\ \frac{z}{A_3} + l_4 f_4 \left(\frac{z}{A_4} \right) - 4\pi(n_1 x + n_2 y$$

This represents a surface, the ordinate at any point of which is the induction through the armature. Such a surface was first described by Doctor John Hopkinson (Lecture before the Inst. of C. E., April, 1883), and is called the "characteristic surface." It must be remembered ν_1 is a constant coefficient, or may be taken as such with sufficient accuracy, but ν_2 is not constant. It is unnecessary to consider further its general form, as it may better be determined in connection with the particular type of machine under consideration. $f_1\,f_2\,f_4$ would be the same functions if the quality of the iron were the same in the several portions of the machine.

Having obtained a general expression for the induction in the armature, the electromotive force in the electric circuit, when displaced, can be deduced by Faraday's law.

Consider now the application to alternate current machines. Such machines are usually multipolar. In machines of the disc type the number of poles is even, and the armature is divided into sections corresponding to the number of poles, and revolves uniformly between them. The tube through any one pair of opposed poles and back through another need only be considered, and the total effect of the machine obtained therefrom by summation. Suppose the iron of both magnets and armature so arranged that no currents are induced therein. There is then only one electric circuit to deal with. The whole current in one

section of the armature cuts the magnetic tube passing through the section as many times as there are convolutions. Let m be the number of convolutions. The current, x, round the magnets is usually derived from independent sources, and maintained constant. For each such constant value the characteristic surface becomes a curve giving the relation between the induction through the armature and the current in it. The areas A_1, A_2 and A_4, and the lengths, l_1, l_2, l_3 and l_4, are constant, but the area, A_3, is a periodic function of the time, and can be expressed by a series of cosines, the coefficients of the series being determined by Fourier's theorem from the dimensions of the machine. The general consideration of the form of ν_2 has been worked out by Doctor J. Hopkinson (Proc. R. S., 1887), and need not be referred to further. The induction is a function of the time; but as an example, consider its value at that epoch when the cores of the armature are exactly opposed to the pole-pieces.

$$\frac{l_1 \nu_1 \nu_2 \mathrm{I}}{\mu_1 A_1} + \frac{l_2 \nu_2 \mathrm{I}}{\mu_2 A_2} + \left(\frac{l_3}{A_3} + \frac{l_4}{\mu_4 A_4}\right) \mathrm{I} - 4\pi n_1 c - 4\pi m \mathrm{C}$$

Since the coefficients are all determinate by measurement or experiment, I is obtained in terms of c and C. Assume that, instead of continuous rotation of the armature, the action of the machine is such that each core of the armature is moved periodically in an infinitely short time from between one pair of poles to the next. Let T be the periodic time, E the electromotive force, then

$$\mathrm{E} = m \frac{2\pi}{\mathrm{T}} \mathrm{I}.$$

Hence E is determined in terms of c and C. E is here the maximum E. M. F. The E. M. F., as measured by a Cardew voltmeter or equivalent instrument, will be $\frac{1}{\sqrt{2}}$ of the maximum.

If the equation of the characteristic be differentiated with regard to the time, we shall obtain an equation of the form

$$\mathrm{A}\, \dot{y} + \mathrm{B}\, y = \text{periodic function of } t,$$

when B is constant and A is a periodic function of t, but usually assumed to be constant, and called the "self-induction" of the machine. In the case of an alternate current machine there are usually other magnetic forces acting upon the electric circuit external to the generating machine. For instance, the electric circuit may contain a transformer, or a second machine inserted as a motor, or an arc lamp in which there is a constant E. M. F. changing sign with the current. It is not then sufficient to consider the magnetic tube within the machine only, but the effect of all other tubes which are cut by the circuit must be included, and the characteristic surface of the whole system obtained by summation. These cases have been worked out, taking A as by Doctor J. Hopkinson. (*Journal of Telegraph Engineers*, 1884.)

Now consider the application to continuous current machines. With the exception of certain types of dynamos, like that of Professor Forbes or the cylinder dynamo of Doctor Werner Siemens, in general no current continuous in direction can be obtained by continuous rotation of any part of the electric circuit, unless arrangement is made for reversing the current at a certain stage of each revolution. If the rotating part contained one section only, the current, though continuous in direction, would oscillate from zero to its maximum. To avoid this the electric circuit is divided into a number of sections, arranged symmetrically on the armature, the current in one or two of which only is reversed at a time. If the number of sections be even and equal to $2\,m$, one-half will be in series, and one-half the total current will pass through each half, except at the instant of commutation. At such time two sections are short circuited, and form complete circuits inwhich the current will be determined by the induction through them at the time; and the number of sections in series will be $m - 1$. If the number of sections be odd and equal to $2\,m + 1$, one section only will be commuted at a time, and at that instant there will be m sections in series. At other times there will be $m + 1$ sections in series on one side and m on the other, and consequently there will be a superposed current flowing through the armature only, due to the inequality in the number of sections in series in the two halves. In one revolution of the armature the tube of induction through it will be cut four times by each section, and if the plane of commutation is symmetrical with regard to the tube of induction, the current in one-half the sections will cut it in the opposite direction to that in the other half. In this case, $n_2 = o$. But any displacement of the plane of commutation from the symmetrical position will cause the current in a greater number of sections to cut the tube in one direction more than in the other. Let λ be the angular advance of the plane of commutation, and m the number of sections in the armature; then $n_2 = \frac{\lambda m}{\pi}$. The value of λ may be fixed for any given machine, or varied at pleasure, or may be determined to avoid sparking at the time of commutation of a section. The general discussion of the value of λ to effect this has not yet been attempted. For the present λ must be regarded as independent. The general equation of the characteristic surface becomes, for a continuous current machine,

$$l_1 f_1\left(\frac{\nu_1 \nu^2 z}{A_1}\right) + l_2 f_2\left(\frac{\nu_2 z}{A_2}\right) + l_3 \frac{z}{A_3} + l_4 f_4\left(\frac{z}{A_4}\right)$$
$$- 4\pi n_2 x - 4\lambda m y$$

λ being reckoned positive when the displacement is in the direction of rotation.

If no current passes through the armature, $y = o$ and ν_2 may be taken as constant and determined by experiment. The equation may then be written

$$l_1 f_1\left(\frac{\nu_1 \nu_2 z}{A_1}\right) + l_2 f_2\left(\frac{\nu_2 z}{A_2}\right) + l_3 \frac{z}{A_3} + l_4 f_4\left(\frac{z}{A_4}\right) - 4\pi n_1 x$$

which is the equation to the characteristic curve of a shunt wound or separately excited machine, and determines the induction for all values of the exciting current. Having determined the characteristic when $y = o$, the characteristic surface can be determined therefrom by considering the form of ν_2. (See J. and E. Hopkinson. *Trans. of R. S.*, part i., 1886, p. 334.)

It has been assumed that the sections of the armature are the only conductors in the field, or that the armature is so constructed that no currents circulate in the iron. This in the best machines is only partially attained. The effect of such currents on the characteristic surface is the same as increasing the current in the armature. If the lead is negative, the induction is increased both by the current in the sections of the armature and in the iron; but such a negative lead must give rise to destructive sparking as the sections will be commuted in a strong field.

ABSTRACTS AND EXTRACTS.

MAN'S CREDULITY.

KEELY ONCE MORE.

At a meeting of the stockholders of the Keely Motor company in Philadelphia, yesterday, a report was read which was said to be a complete review of the inventor's efforts and experiments as far back as 1882. We have read a synopsis of this document, and are forced to the opinion that it is very far from being a "complete review" of what Keely has done during these memorable five years. It does not half do him justice. He has during that period made a series of discoveries which were so remarkable that neither he nor anybody else has ever been able to define them in intelligible language. No man could read or hear the definitions given of them without becoming convinced that things which it put such a strain upon the powers of language to define must be wonderful in some way or other. We propose to compile a review of Keely's work during these five years, in order to counteract the injustice done him by the document read yesterday.

There had been hints of a great discovery by Keely early in 1875, but little definite was known until he published a card, about the middle of June, 1882, in which he said that he had reached a point in his experiments at which he could safely communicate his secret. He declared that he had discovered a great natural force, denominated by him an "etheric force," which exercised a pressure of 25,000 pounds to the square inch. How he obtained the force he did not make entirely clear, but so far as could be made out from his language he generated it by the comparatively simple process of pouring a pail of water into a hole. He announced that the mechanical appliance for using the force was "vibratory in character," and that he was about to get a patent on the discovery. He never did get it, and we presume the reason was that a patent was refused on the ground that the art of pouring water through a hole, having been known to man from the earliest times, was not an invention of Keely's. As for the force itself, he could not get a patent on that without disclosing it, and he could not disclose it because of the inadequacy of human speech to convey an idea of it. It was one of those mysterious agencies which could not be disclosed to the senses.

Keely's card did not satisfy some of the stockholders who had put $150,000 into the discovery, and they applied to the courts and obtained a judicial order directing him to disclose the nature of the invention and get a patent for it. A scientist named William Boekel was appointed to receive the secret. It was about two months before Mr. Boekel was able to comprehend what Keely was communicating to him. After seven weeks of constant revelation he declared that he was still unable to understand the discovery, and was induced to think that "recognized mechanical sciences cannot reach the thing." A week later, however, he filed a report in which he declared "unhesitatingly" that Keely had discovered a "new force of motive power,"

which he described as a "substance evolved by him through the instrumentality of his structure." This substance was a "vaporic or etheric force," and possessed "properties peculiar to itself and wholly phenomenal in character." "Time, patience, the closest attention," and the "study and application of vibratory forces" would be necessary not only to permit Keely to "perfect its utilization," but to "give such technical descriptions thereof as to meet the requirements of the law, as the condition of obtaining valid letters patent." Mr. Boekel's report was chiefly useful in showing that Keely's eight weeks of revelation had resulted in making Boekel's language as unintelligible as that of Keely himself, and this was a demonstration that a phenomenal force of some kind had indeed been discovered.

In December of the same year, Mr. Boekel communicated further on the subject to the stockholders, saying that the secret was in a fine condition, that the force had been utilized by Keely in an engine which "disintegrated" water so that its "molecular structure was broken up," and "therefrom was evolved a permanent expansive gas, vapor, or ether, which result was produced by mechanical action." The stockholders were unable to understand this, but were told that they would understand it when it was applied, as it soon would be, to a train of cars on the Pennsylvania railway. There was a long silence after this meeting, probably due to the mental exhaustion of the stockholders from attempting to understand the language of Boekel and Keely. In November of 1883 some of the stockholders became restless and talked about sueing Keely, but were quieted by the information that no good would come of it, since he alone possessed the secret, and as he was unable to make anybody else understand it, the company would simply destroy its own property by bringing suit against him and stopping his work.

The year 1884 was a very active one with Keely. He sent out a circular in February, in which he said he was able "to state positively (as regards the mechanical) that the first of the coming month will find all thoroughly completed, and there will be nothing left but setting up the transitive process, when all labors will terminate, preparative to operating and showing up the specific qualities of the perfect vibratory engine." The only point upon which there was doubt was as to the time necessary for "the line of graduation." This might take days, or weeks even, but he was sure that the "final issue was nigh at hand." About a month later announcement was made that all the "subordinates" who had been engaged for years in the construction of the motor had been discharged because their work was ended, and that Keely from that date would be shut up alone with the motor, and would devote all his energies to "focalizing and adjusting the vibrators." This, the world was assured, was an extremely delicate operation, which no living man except Keely could perform, but it would be mere child's play for him, and would end so soon as he obtained "one revolution."

Keely remained alone with the motor from March till September, when he emerged with the startling announcement that he had abandoned temporarily the work of "adjusting and focalizing the vibrators," and had invented a gun which would be used to demonstrate the power of the "force" or "etheric vapor." He held an exhibition at Sandy Hook soon afterwards, when ordinary scientific people declared that the "etheric vapor" was nothing more nor less than compressed air, but Keely said he would put these scoffers to shame very shortly by constructing two engines, one of 250 and the other of 500 h. p., and run them both by "etheric vapor." He said his principal difficulty had been to "bridle the force," but he had got it under control at last.

A period of quiet followed till June, 1885, when Keely held an exhibition in Philadelphia, and astonished everybody by bringing out the motor in still another form. This time it was an "Inter-Etheric Liberator," which was operated by an extraordinary combination of a "tuning-fork," a "fiddle-bow," a "disintegrator," "resonators," "wave-plates," "electric conductors," "confined vapor," and the "suction of Keely's mouth." Everybody who witnessed the exhibition was so dazed that he could not talk intelligibly, but that of course only showed once more what an inventor Keely was. All that the eye-witnesses could say was that when Keely, by applying his mouth to a thick tube, had established a "partial vacuum," and then going across the room had drawn a fiddle-bow across a tuning-fork, he "caused the 'Liberator' to act," and "things began to hum" at a tremendous rate of speed. A globe turned at the rate of a thousand revolutions a minute; a solid plank placed against its revolving periphery was torn into splinters; small leaden balls were shot out of a cannon; an engine was driven at a terrific rate of speed; and several other things were accomplished. But, as usual, language failed to explain how it was all done. In May, 1886, a similar exhibition was held with the same "Liberator," when a disturbance was raised by an ordinary scientist asking the privilege of performing the same experiments without a tuning-fork. Keely considered this request insulting, and the scientist was ejected. Keely said that within sixty days he would have an engine in operation and would take out his patents.

All has been quiet since till now, when Keely comes forward and says that new "phenomena have been unfolded" to him, opening a new field of discovery, and that he shall abandon the "etheric force," the "Liberator," and all other former forces, and shall conduct all his experiments with a new force, for which he has not an exact name, but the "basis of which is vibratory sympathy." He proposes the formation of a new company with a capital of $15,000,000. The old company has sunk many thousands of dollars in the "etheric force," and we presume that their "vibratory sympathy" is exhausted. Keely has at last hit upon the right name for his force. Its sole power consists in the amount of "vibratory sympathy" his experiments can arouse in the pockets of gullible capitalists.—*The N. Y. Evening Post*, Dec. 15.

THE DISEASES OF DYNAMOS.[1]

BY PROF. SILVANUS P. THOMPSON, D.SC.

CONSIDERING the widespread use of the dynamo-electric machine, and the mass of literature concerning it that has sprung up, it seems remarkable that no one should as yet have written upon the topic of the maladies to which such machines are liable, their treatment, cure and prevention.

Not once or twice has it occurred in the writer's professional experience to be called into consultation over some hitch that has arisen in the maintenance of an electric light installation where the experience of the engineer and the knowledge of the electrician in charge had failed to discover the cause of the breakdown, or suggest an appropriate line of action. Under such circumstances one cannot help comparing oneself to a physician called into consultation over a patient. And as a knowledge of the diseases of dynamos and their treatment form a necessary part of the complete training of the electric engineer, an attempt by a specialist to elucidate the subject and systematize it, may appropriately be brought before such a society as this, comprising as it does many electrical engineers.

Moreover, as some of the members of this society have had large and diversified experience in the construction, erection, use, maintenance and repair of dynamos, the writer hails this opportunity of inviting an interchange of expression from all members present respecting the causes that lead to the breakdown of dynamos and their prevention.

The diseases of dynamos, like those of human beings, may be classified under several heads, whether constitutional or acquired, whether curable or incurable, whether surgical or medical in the treatment required.

The constitutional diseases may arise either from defective design or imperfect construction. A ricketty constitution in a dynamo may result either from inherent badness in the forms of those parts which should give strength to the structure, in the employment of bad or faulty materials, or in bad workmanship. Diseases acquired as the result of overwork and of neglect, though classified as acquired rather than constitutional, are more likely to be developed where there is a constitutional weakness. The physician who is called in must have the eye to detect the constitutional taint, as well as the more obvious present causes of mischief. When called into consultation upon a human subject, the physician's first inquiry is as to the symptoms that present themselves. Perhaps a clinical examination is necessary to learn the whole of the symptoms in the case. The diagnosis of the case being completed, a course of treatment suggests itself, which course may be of several kinds. A surgical operation may be necessary, or perhaps bandages and poultices may accomplish all that is required. It may be proper to administer drugs; or in milder cases a change of climate or diet is all that is prescribed. Simple rest accomplishes wonderful cures; but in neglected cases long and careful nursing may be the only hope.

It may safely be said that at least four-fifths of the breakdowns that occur with dynamos—whether partial or total—arise from causes that are more strictly within the province of the engineer than in that of the electrician. On the other hand, many of the mechanical faults that develop themselves in the machine might have been avoided had the engineer possessed a better knowledge of the electric and magnetic conditions that obtain in the running of the machine. It is not often nowadays that armatures fly to pieces. That disaster has seldom occurred since good engineers took in hand the construction of dynamos, though it was, relatively to the number of machines used, a not unfrequent occurrence in the days when armatures were mostly designed by electricians who had little or no knowledge of mechanical engineering. On the other hand, any engineer will make a poor builder of armatures who does not understand the nature of the reactions that occur in the magnetic field—how a conductor carrying a current is subjected in the magnetic field to a mechanical force exerted upon it without any visible means of transmission. If he does not understand this, he will not grasp the necessity of so designing and constructing the armature and its spindle that the power applied to the spindle shall be conveyed directly to drive the peripheral conductors. He cannot realize that it is

1. Paper read before the Finsbury Technical College Old Students' Association, Nov. 29, 1887.

the copper wire, and not the iron cores, that primarily require to have the power applied to them. He may know that insulation is necessary, and that lamination of iron cores is necessary; but he may, for want of full electrical knowledge, apply both the insulation and the lamination in an entirely erroneous manner, and produce a dynamo that will break down directly it is put to any severe test.

Amongst the complaints to which armatures are subject are the burning-out of coils, the burning of the binding wire, and the breaking off of the conductors near the ends where they go to join the respective parts of the collector. The burning-out of coils is sometimes due to short-circuiting at the collector between two adjacent sections; but often it arises from short-circuiting in the armature itself. In armatures so constructed that the windings of one section lie partly over the top of those of another section this evil is more likely to occur than in those that are not so constructed. Short-circuit between an imperfectly insulated wire and the iron core beneath it is a frequent source of trouble, and this again arises either from bad mechanical work allowing the iron laminæ to become loose, or from the use of unreliable insulating materials. Sometimes armatures are destroyed by charring of the insulation, not in consequence of the overheating of any of the wires, but from the overheating of the iron cores. In such cases either the iron is not properly laminated, or else the insulating material between the iron laminæ has failed to insulate. The burning of binding wire clearly arises from want of compliance with the necessary and sufficient electrical conditions. The fracture of the armature conductors near the ends where they turn over to the collector—a most annoying fault when it occurs—appears to be partly mechanical and partly electrical. These conductors are, at this point, not supported laterally; any engineer would imagine that they were strong enough to stand any longitudinal or centrifugal force to which they might be subjected. Yet they have to withstand severe lateral forces, arising from the fact that they carry strong currents and are situated in a fairly powerful part of the magnetic field, which here extends beyond the edge of the polar surfaces. Hence they are each racked by a lateral force that comes upon them twice in every revolution; and which, moreover, must strain them severely whenever the current is suddenly cut off or turned on. The collector, or commutator, and its brushes are a fruitful cause of trouble. Brush-holders are rarely as substantial as they should be. The conditions of good mechanical work and good electric work are here somewhat antagonistic; but the mechanical work must be good, otherwise the best observed electrical arrangements will fail. The brushes must not slip or jump with the vibrations of the machinery. If they press too heavily, the surface of the collector will be torn into ruts; if too lightly, the edges of the separate sections of the collector will be bitten and rounded by sparks. The curious disease known as the occurrence of "flats" in the collector has been a source of puzzle and annoyance to many. In many cases the occurrence of a "flat" may be definitely traced to a more or less developed fault in some one section of the armature coil. A broken armature coil, the ends of which still touch against one another within their insulating sheath, may go unsuspected; but it may have the effect—by its increased resistance—in causing an increase of spark at the brush just as it passes through the position of commutation. Hence the corresponding bar of the collector will, at every half-revolution, be bitten into by a spark a little more than any other bar is bitten into, and so become flattened as compared with the proper peripheral curvature of its fellows. "Flats" do not, however, always arise from this cause. It has been observed that a "flat" may break out on one bar of the collector; and on turning down the surface of the collector so as to remove it, a "flat" breaks out on another bar of the collector. A "flat" may arise from a flaw in the metal of the bar, which passing under the brush, gives rise to a spark that bites away the metal a little further to right and left, and so spreads along the bar until the whole surface of it is more or less bitten away. A little more pressure on the brush, and a better mechanical holding of the brush, are remedies not to be despised. The collector is the one part of the machine most likely to give trouble; it is rarely made large enough; years of experience have not yet given any decisive answer to the question, what materials it should be made of? Whilst English makers are almost agreed upon using either hard-drawn copper or else some kind of hard bronze with mica insulation between the bars, Messrs. Siemens & Halske have this year abandoned these for iron bars with air gaps between. Before mica was in general use asbestos was not unfrequently employed, and with curious results. At one time the writer was working with a small Siemens shunt dynamo, giving on open circuit about 80 volts One day it gave only a little over 70, though the speed was normal. The next day it was under 70, the next it refused to excite itself. The circuits were tested out, as a fault in the shunt, increasing its resistance, was suspected; but there was nothing found wrong. When separately excited from accumulators, it, however, only gave 15 volts on open circuit. In vain the brushes were replaced and the brush holders cleaned. There was plenty of magnetism, for the armature got hot; yet no sparks, or next to none, at the brushes, even when short-circuited. Suspecting that some of the armature coils were short-circuited, an attempt was made to test the resistances between bar and bar of the collector, but without any very decisive results, owing probably to the roughness of the test. However, there were noticed some slight inequalities, which gave a clue to the cause of trouble. On examination it was found that nearly every one of the collector bars was more or less short-circuited to its neighbor by a charred mass of carbonized oil imbibed into the asbestos which formed the insulation. It was dug out with a penknife and replaced by another material, when the dynamo was restored to its proper activity. This vice has been of not unfrequent occurrence. Only a few weeks after the occurrence named the writer received an urgent call to go to a town in a distant part of England, where a dynamo refused to work. Being unable to leave home that day particular inquiries were addressed by telegraph, and yielded the information that it was a Siemens shunt machine, that all the circuits tested right, but still the machine would not excite itself. Instructions were despatched to dig out the insulation between the collector bars, and the remedy proved effectual. Obviously, in such cases, oil ought not to be used on the collector, but only asbestos dust or French chalk. The writer has subsequently learned that a very similar trouble sometimes arises in certain machines that have collectors so constructed that there is a cylindrical cavity beneath the collector bars into which oil from the lubricators at the bearings may drain, and in which a charred mass ultimately forms, short-circuiting the entire collector. Another cause of trouble is the small metallic dust which flies from the collector when the brushes press so heavily as to produce ruts, entailing consequences partly mechanical and partly electrical that may end in a breakdown.

Amongst other faults of armatures that give trouble there is a purely mechanical one, arising from want of knowledge on the part of the electrical designer, namely, that of not being properly balanced. Every engineer worthy the name knows that a thing so balanced as to stand in any position is not necessarily balanced for running; that a four-pound weight at three inches from the axis of rotation, though balanced statically by a one-pound weight at twelve inches from the axis, is not balanced by it dynamically, for the moments of inertia about this axis are not equal. On the contrary, a four-pound weight at five inches is balanced dynamically by a one-pound weight at ten inches from the axis. A machine that violates dynamical principles can never be satisfactory. Short bearings where long ones would be appropriate; a high-speed machine where a low-speed machine is the only suitable sort (for example, on shipboard); inside bearings where outside ones ought to be used, and *vice versa*—all these things have been and may still be answerable for breakdowns. So much the more reason is there for the electrical engineer to be engineer first and electrician afterwards. Not that electrical knowledge is to be despised. The writer once heard an experienced engineer who had been put in charge of a dynamo which was lighting some arc lamps, and doing its work badly, declare that the trouble arose, not from an insufficient supply of current—he did not dispute the quantity of the current—but from the current being of a rather poor quality. There were, in point of fact, too many lamps in the circuit. Again, it is a fact furnishing food for reflection that in those electro-plating shops in London where dynamos are used, the practical men in charge almost invariably hold the firm opinion that they are not getting the proper current unless they can see sparks at the commutator. They therefore so adjust the brushes that they get a good blaze. Sparking at the commutator or collector is a symptom of disease in a dynamo, just as truly as an outbreak of pustules is a symptom of disease in the human subject.

In the field-magnets vices of construction are more frequent than acquired defects. Field-magnet coils are sometimes wound on frames that are loose, or the coils are badly insulated. When the frames are loose the resulting vibration not unfrequently causes the ends of the wires to snap off short. If there is a single short-circuit between coils and iron-work in the field-magnet, then a single short-circuit at any other point—armature coils, collector bars, brushes, brush-holders, or terminals—may work dire disaster. A little Brush machine lent to the Finsbury Technical College by the Anglo-American Brush Corporation had its commutator segments completely ruined in a few minutes by a curious double fault of this kind, which defied detection for several days. There were two short-circuits, neither of which, in itself, would have done any harm whatever; but the iron support that held the rocker for one pair of brushes was so fixed by screws as to make a cross connection that short-circuited two pairs out of the four pairs of coils on the armature. A short-circuit between coil and iron core of the field-magnet is more likely to arise in shunt machines or compound machines than in series-wound ones, owing to the much higher electromotive force of the self-induced extra current if the shunt-circuit is from any cause opened. Alternate current dynamos are liable to develop different kinds of faults from those to which direct-current machines are liable. They sometimes exhibit a curious pulsation of a determined slow period in their currents. The cause for this is probably purely mechanical. Again, machines for constant current are liable to disorders of a different nature from those of machines intended for constant potential work. The latter are

more liable to overheat; the former are more troublesome in respect of sparking, because of the very great variations in the position of the neutral point.

Very little attention seems to have been paid to the question of the goodness or badness of insulating materials for resisting being broken down under working conditions entailed by damp, dust, and oil. Under such conditions it does not in the least follow that the material showing the highest insulation tests is the best. Very few dynamos will show, even when new, an insulation-resistance between iron work and copper work amounting to anything like one megohm. Yet a dynamo that showed only 10,000 ohms of insulation-resistance and mechanically resisted being broken down, would be preferable to one the insulation-resistance of which was a hundred megohms, if that high resistance were secured by employing brittle materials, or materials that were destroyed by the presence of oil. Whether mica is in all cases preferable to asbestos, Willesden paper to vulcanized fibre, or shellac varnish to a solution of india-rubber, or what other insulating materials should be prescribed in preference, can only be ascertained by a careful study of the failures that have from time to time arisen when one or other was employed.

Only by the study of the malady as it arises can the proper treatment be discovered to prevent its recurrence. In short, by the proper study of dynamo-pathology, we may arrive at a fuller knowledge of dynamo-therapeutics.

DISCUSSION.

Mr. Jones, referring to pulsation on alternate current circuits, said that in one case in London, where two such machines were used, he had traced a very troublesome pulsation to the collector, which had worn oval. The fault was removed by turning up the collector.

Mr. Esson was of opinion that engineering faults were generally the cause of breakdowns. Speaking of the relative merits of armatures in which the wire was supported by metal projections, and of those where the wire was held on merely by friction, he stated that he had never seen a fault from the wires being attached in the latter manner. The breaking of wires leading to the commutator was more common in motors than in generators. He thought it was due to the spindles bending. For commutators he recommended gun-metal, where great pressure was required to prevent vibration, as in motors on tram-cars; in other cases hard-drawn copper, lubricated with vaseline. He thought that unequal sparking of brushes was due to the field being made unequal by the presence of masses of iron about one of the poles.

Mr. Mordey thought the fault of the breaking of wires near the commutator was an obscure one; it had never been quite satisfactorily explained. He recalled a paper published some five years ago by Hefner von Alteneck, in which the fault was discussed, but left unexplained. Professor Thompson's suggestion was a good one, but he thought that the first effect of the movement of the wires in the fringe of the field should be to give them all an inclination in one direction. This did not occur, and he thought, therefore, that Professor Thompson's suggested explanation was not quite satisfactory; neither did Mr. Esson's quite fit in with many cases where the fault had been observed—that was in the steady running of dynamos. The fault had never occurred in Brush or Victoria dynamos. The pulsation in alternating current dynamos was often noticeable. In one large installation in London, where the dynamos were driven direct, the pulsation was very marked, and appeared to be too quick to correspond with the speed of the engine, and too slow to be due to the actual alternations. Referring to commutators, he said that various lubricants had been recommended. Sir William Thomson was credited with advancing the claims of treacle for this purpose. He thought that the lubricator was the least important matter in successful collection; nor was it very important how the brushes should be made, provided they were not too thick. Carbon had been recommended for brushes, but he thought carbon should be reserved for the arc lamps. The unequal sparking and heating of brushes had often been noticed, and he was inclined to attribute it to an effect similar to that which occurred in arcs, where one electrode got hotter and burnt away faster than the other. He asked others to try, by reversing the polarity of the magnets, whether they could confirm or disprove him. The difficulty was that sparking in modern dynamos was usually very slight, and convincing results were difficult to obtain. The effect of any inequality of the distribution of the fields would be removed by reversing the polarity of the magnets. After describing some simple methods for localizing faults in low-resistance armatures—matters in which ordinary bridge and other measurements were of no use—he referred to the question of insulating materials, on which Professor S. P. Thompson had made some observations. Vulcanized fibre was a very unsatisfactory insulator. The material itself was probably good, but he thought the manufacture could not be carefully conducted, as the substance frequently broke down in a way which seemed to indicate that metal filings or other foreign substances were rolled into the sheets. While acknowledging that dynamos were liable to suffer from many diseases, he thought they should not be too harshly blamed, and mentioned a case where, of two similar machines, one was always found to require a higher speed of the engine and apparently to absorb more power than the other. He traced the loss to a friction clutch which had been allowed to become covered with oil, and was slipping and absorbing about 18 h. p.

Mr. D. Pearce said that he had found the insulation of some Siemens dynamos was very low, the paint used having quite soddened the cotton with oil. He mentioned a case of unequal heating of brushes, where the positive brush always wore several times as fast as the negative. The fields had been reversed, but without effect.

Mr. Sumpner said that, in taking the curve of a Ferranti dynamo, he had found that there was an occasional departure from the sine curve, caused by an inequality of the winding.

To this Mr. Mordey objected that, as all the armature coils were in series, all the curves must be alike, any inequality affecting the curve similarly at every alternation.

Professor Thompson remarked that an inequality in the armature winding and another in the field would account for the discrepancy, which would then occur once in every revolution.

After some remarks from Mr. Howard Swan, Mr. Dickson, and other members, and from Mr. Pettigrew, who occupied the chair, Professor Thompson replied. He said that the thickness of brushes should be such that the current should have time to die out of the coil, under the brush, to start again, and to come up to the strength of the main current before the coil was again thrown into the circuit. He did not quite give up his idea that the breaking of wires was due to the magnetic field. The sudden putting-on of the current in motors would account for the increased occurrence of the fault in them. In motors the brushes might be wider than in generators. Alteneck had told him that the fault had been entirely got rid of by connecting the segments to coils 90 degrees removed from them. He thought, and had previously pointed out, that unequal fields were often a cause of sparking, and that on this account double magnets had an advantage.

A cordial vote of thanks to Professor Thompson for his interesting and instructive paper terminated the proceedings.

A TALK ON TRAMWAYS.

At the meeting of the New York Electrical Society, held on Nov. 30th, Mr. Holroyd Smith, of London, gave a "Talk on Tramways," in which he treated the subject of street railroads, first in a general way, and then with special reference to the electrical method. In beginning his address, Mr. Smith said that too much attention cannot be given to the fact that in electrical railroading the electrician occupies the second place to the engineer, and that the past failures in electric railroading have been due to the fact that electricians, pure and simple, have gone into the domain of engineering without sufficient knowledge to guide them. In other words, the electrician must not expect to succeed in working tramways unless he studies the engineering problems as well. Mr. Smith, in taking up the subject generally, drew attention to the fact that American railroads, or tramroads, were the necessary outcome of the generally bad ordinary roads, whereas in England the roads are uniformly good. While in America the centre bearing rail is employed almost universally, in England, and abroad generally, such a rail would not be permitted, and recourse must be had to the grooved rail. Hence, while with American cars and rails the coefficient of traction amounts to about only eight pounds to the ton, the English rail requires 23 pounds to the ton, so that these things must not be lost sight of in designing cars. It will thus be seen that conditions vary considerably in different countries, even when seemingly they are quite alike. Mr. Smith asserts that the increased power claimed for the driving motors is due to the overestimation of the power required to move the car.

Mr. Smith then entered into the consideration of traction by horses, compressed air, steam and cable, and deplored the fact that while in England the statistics of running expenses of horse car lines were well known and published in Duncan's *Tramway Manual*, we had no such source of information, and it was with the greatest difficulty that any reliable figures could be obtained with regard to the subject on American lines. Mr. Smith stated that as a rule in England a 2-horse car running for 14 hours a day required 10 horses. These horses cost £30, and had an average life of three years. In discussing the question from the electrical standpoint, Mr. Smith drew attention to three essential points that have to be considered: 1. Safety to the public. 2. Efficiency. 3. Economy.

Taking up the storage battery first, Mr. Smith held the position that even if the battery could be successfully worked, it would cost one-third more to equip and run a line on this system than to put down a conduit, and especially would this be the case where traffic is very heavy. Mr. Smith was of the opinion that of the various systems the overhead system was the best, taking all into consideration; but the great danger in its use lay in the tendency to do slipshod work. The difficulties met with at crossings and switches in railway work where conductors of opposite polarity met in a horizontal plane are overcome by placing the conductors in a vertical plane, so that even if contact

does occur it can only happen between two positive or two negative conductors. Mr. Smith finally described a new method of his own which was designed to overcome all the objections to both the overhead and underground circuits, and which, without the use of the storage battery, is arranged to supply the motor on the car with electricity. This system, which was only hinted at by the speaker, will no doubt attract some attention in the future.

In the discussion which followed, Mr. T. W. Rae spoke of the experiments made on cars in this city by Mr. C. E. Emery, the well-known engineer, who found that the coefficient of traction was 12½ pounds per ton; and General Q. A. Gilmore states that the general average for the whole country is 16⅔ pounds per ton.

Mr. R. G. Blackwell, whose opinions on this subject are well known, deprecated the use of the storage battery entirely, and, in replying to a question, remarked that the delay in the construction of the Fulton street road in this city, undertaken by the Bentley-Knight company, was due to legal complications; and that all the material required for the road was in store in this vicinity, ready to be applied at the earliest notice.

Mr. C. O. Mailloux in replying to Mr. Blackwell, detailed the experiments which are now going on upon the Madison avenue line in this city, on a car equipped with 120 cells of Julien storage battery, and which ran from 85th street to Harlem Bridge and back, on a run of 40 miles, with a drop of but two volts. Mr. Mailloux stated that the Brussels Tramway Co. are now operating 10 cars of this system and that before many months have elapsed New York will see as many storage cars in operation. Mr. Mailloux drew special attention to the fact that storage batteries were well adapted to long lines on account of the large conductors required with the overhead and underground systems, where the drop of potential has to be made as small as possible.

Mr. Holroyd Smith confirmed this statement of Mr. Mailloux, but he still claimed that the use of the storage battery was only a transient one. In reply to a question by Mr. Davidson as to whether a conduit had ever been operated in this country, Mr. R. G. Blackwell referred to the experimental line operated in Cleveland on the Bentley-Knight system, and carried on through snow, ice and water without trouble. Mr. Smith also confirmed this fact, and stated that the last winter had been most severe in Blackpool, England, where his road was in operation, but notwithstanding this, the current had practically not stopped in three years since the road went into operation.

After the close of this discussion, Mr. G. F. Harris brought before the society a slip of the cable record made by one of the first Thomson siphon recorders, on the cable between Vigo and Penzance, and also made a few explanatory remarks relative to cable work.—*The Electrical World.*

THE BESSBROOK AND NEWRY TRAMWAY.

BY DR. E. HOPKINSON.

THE following is an abstract of a paper read at the ordinary meeting of the Institution of Civil Engineers on Tuesday, the 6th of December, by Edward Hopkinson, M. A., D. Sc., A. M. I. C. E.:—

"Although a number of electrical tramways had been constructed in the United Kingdom during the last few years, there had hitherto been no attempt at the regular haulage of minerals and goods, nor at the operation of cars larger than the ordinary tramway type. Probably in no case had the effective power of any single motor exceeded about 4 h. p. The principal object of the present paper was to describe the construction and to discuss the working of the Bessbrook and Newry Electrical Tramway, which had been designed for the haulage of heavy goods as well as for passenger traffic. The length of the line was rather more than three miles, with an average gradient of 1 in 86, the maximum gradient being 1 in 50. According to the conditions of the contract ten trains were to be run in each direction per day, providing for a daily traffic of [illegible] tons of minerals and goods, and capable of dealing with 200 tons in any single day, in addition to the passenger traffic. The electrical locomotive was to be capable of drawing a gross load of 18 tons on the up-journey, in addition to the tare of the car itself and its full complement of passengers, at an average speed of 6 miles per hour, and a load of 12 tons at an average speed of 9 miles per hour. Also, the cost of working, as ascertained by six months' trial, was not to exceed the cost of steam-traction on a similar line. The line was formally taken over by the company, as having fulfilled the conditions of the contract, in April, 1886, and had since been in regular daily operation. It was worked entirely by water-power, the generating station being adjacent to the line at a distance of about one mile from the Bessbrook terminus. There were two generating dynamos of the Edison-Hopkinson type, driven by belting from the turbine shaft, which was extended into the dynamo shed for the purpose. The turbine could develop 62 h. p., and each dynamo was intended for a normal output of 250 volts 72 amperes, though they were capable of giving a much larger output. The current was conveyed to the locomotive cars by a conductor of steel, rolled in the channel form, laid midway between the rails, and carried on wooden insulators nailed to alternate sleepers. The conductor was not secured, but was simply laid upon the insulators, which fitted into the channel, and while allowing for longitudinal motion to compensate for changes of temperature, held it laterally. At one point the line crossed the county road obliquely, the crossing being 150ft. in length. In this case the conductor on the ground level was not feasible, and an overhead conductor on Dr. John Hopkinson's system was substituted, by which the collector on the car consisted of a bar only, which passed under the supports of the overhead wire, and made a rubbing contact with its under surface. This system had been found to give very satisfactory results in practice.

"The locomotive equipment of the line consisted of two passenger cars, each provided with a motor. The body of the car was carried on two four-wheeled bogies, the motor being fixed on the front bogie, so as to be entirely independent of the body of the car. The longer of the two locomotive cars was 33ft. in length, and was divided into three compartments, the front one covering the motor, and the two others forming first and second class compartments, together accommodating 34 passengers. The front bogie carrying the motor had an extended platform, projecting beyond the body of the car, and communicating by a slide door with the dynamo compartment, thus giving the driver direct access to all parts of the driving machinery, which was at the same time entirely boxed off from the passenger compartments. The weight of the locomotive, including the dynamo, was 8¼ tons.

"Apart from the electrical working of the line, an important and novel feature was the plan by which the wagons used on the line could also be used on the ordinary public roads, so avoiding the necessity of trans-shipment, and enabling goods to be loaded at the wharves and drawn to the line by horse-power and again delivered where required. The plan was originally suggested by Mr. Alfred Holt, M. Inst. C. E. of Liverpool, and was embodied in the Lancashire Plateway Scheme, for which a bill was lodged in the autumn of 1882 and subsequently withdrawn. The idea had been worked out in a practical form with great success by Mr. Henry Bancroft, of Newry, one of the directors of the Tramway company. The wheels of the wagons were constructed without flanges, with tyres 2¾in. wide, which was sufficient for use on ordinary roads. Outside the tramway rails, which weighed 41.25lb. per yard, second rails were laid, weighing 23.75lb. per yard, with the head ⅞in. below the head of the larger rails. The flangeless wheels ran upon these lower rails, the ordinary rails forming the inside guard. The front part of the wagon was supported on a fore-carriage, which could either be pinned or allowed freedom of motion, as in an ordinary road vehicle. There was a single central coupling arranged to engage in a jaw on the fore-carriage, so as to guide it when not pinned. Shafts were attached to the fore-carriage when the wagon was to be used on the ordinary roads. The wagons were of sufficient strength to carry a load of 2 tons, and their weight without the shafts was 23¼cwt. Experience had shown that the wear and tear, both on the wheels and rails, was not excessive, and that the traction did not much exceed, if at all, that of ordinary trucks with flanged wheels. No difficulty had been found with the [illegible]-traction on ordinary roads, and the taking on and off was conducted with great rapidity.

"Each locomotive car was fitted with an Edison-Hopkinson dynamo, which was geared by means of helical-toothed wheels, and a chain to one axle of the bogie. The special construction of driving chain, rendered necessary by the severe conditions under which it had to work, was fully described. The trains were commonly composed of one locomotive car and three or four trucks; but frequently a second passenger car was coupled, or the number of trucks increased to six. Thus a gross load of 30 tons was constantly drawn at a speed of six or seven miles per hour, on a gradient of 1 in 50. The cars could be reversed by reversing the current through the motor without change of lead, but as there was a loop at each end of the line, reversal was only required when shunting in the sidings. The terminal loop-curves were 55ft. radius only, but these were traversed by the long locomotive cars with perfect ease, to which the method of carrying the motor-dynamo on the bogie largely contributed."

The author concluded the paper with a discussion of an extended series of experiments to determine the efficiency of the whole combination under various conditions, and the distribution of the losses. The results were illustrated in a graphic form by a series of curves. Under average conditions of working the total electrical efficiency was shown to be 72.7 per cent., the losses being distributed thus:—

Loss in generator	8.6	per cent.
" leakage	5.7	"
" resistance of conductor	6.6	"
" motor	7.7	"

The friction of the bearings in both generator and motor, and the power lost in the driving gear, were excluded from these results.

In an appendix to the paper the cost of the electrical equipment of the line was summarized, and the cost of haulage per train mile was shown to have been 3.3d. over one period of five months, when the goods traffic was light, and 4.2d. when the goods traffic was heavier. Since the opening of the line the locomotive cars had registered a train mileage of 40,000 miles, and the tonnage had exceeded 25,000 tons, and the number of passengers 180,000.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Another Competing Telegraph to be Established.—A Second Telephone Conference.—Ex-Senator Kiernan's Tribulations.—An Electric Light War in New Brunswick, N. J.—Capital Punishment by Electricity.—Electric Mail Despatching.

IN spite of the recent experience of the Baltimore & Ohio Telegraph Co., a movement is already on foot to establish a new system of competing telegraph lines. The project bears the imprint of being feasible, but the plan is not new. It is based upon the leased wire business, which has of recent years proved a reliable source of revenue and such wires could be utilized for ordinary telegraph service at night. This was the scheme upon which the Mutual Union Telegraph Co. was organized. The projected company is expected to undertake a general press service to occupy its wires at night. It is also proposed to place the wires underground through cities in order to avoid obstruction by the municipal authorities. All of this can be accomplished if the requisite amount of money can be secured. It appears quite natural to suppose that the time may come when it will be impossible to raise funds for the construction of opposition telegraph lines, but it is evidently still in the dim future.

The interchange of opinions at the telephone cable conference held in September at the new telephone building was productive of so much valuable information, that another conference was recently called to take up and discuss other practical subjects. Among those in attendance on December 21st, were Thomas D. Lockwood, W. J. Denver and Isaiah H. Farnham, of Boston, Henry Metzger, of Pittsburgh, W. D. Sargent, of Brooklyn, E. D. Hall, A. S. Hibbard, J. A. Seely and Jos. P. Davis, of New York. The conference was strictly private, but it is believed to have been devoted to the question of switch-boards and the administration of telephone exchange affairs in general. The secret character of these conferences is advantageous in many respects, as those present feel at liberty to speak freely as to the merits of various descriptions of material and apparatus, as well as the general policy of telephone management without fear of its effect on the outside public.

Ex-senator John J. Kiernan has not cleared himself of the financial difficulties in which he has become involved. Suit has been brought against him by the Columbia Rolling Mill Co., of New Jersey, for the amount of certain promissory notes which he gave in exchange for capital stock of the company. Full information of the affair was sent out over the tape of the rival system operated by the Stock Quotation Co., which appears to have made serious inroads upon the once flourishing news agency of Kiernan and Co.

There is another electric light war in New Jersey. This time it is at New Brunswick, where the gas company is striving to obtain a franchise which will enable it to place electric lights in every street and alley in the city, and it also proposes to erect iron posts. The electric light management claim that this is merely an attempt to crush their enterprise, while the gas people retort that if they had agreed to pay down a certain sum of money when the electric light company was first talked of, it would never have engaged in business.

The commission which was appointed two years ago to inquire into the advisability of adopting some more humane method of capital punishment than hanging, expects to complete its report for the new state legislature early in January. It is authoritatively stated that the members have finally agreed to recommend electricity for the purpose. It is certainly open to question whether this branch of electrical development will increase the popularity of electric lighting for general use, as the frequent fatal accidents are not to be readily explained to the entire satisfaction of the public.

There is a scheme hatching in Baltimore for an electric elevated mail railway, which if successful is expected to revolutionize the transportation of light packages. The time occupied between Baltimore and New York for this service is estimated at one and one-quarter hours. The prompters of the enterprise are, as usual, exceedingly reticent. The most that has been done towards starting the system is the filing of a caveat, and organizing what is known as the Electrical Despatch Co.

NEW YORK, Dec. 21, 1887.

PHILADELPHIA.

Public Electric Lighting Questions.—The Philadelphia Bell Telephone Co. Still Seeking Underground Permits.—A General Inquiry Into Underground Franchises.—The Franchise of the Penn Electric Light Co.—The Affairs of that Co.—Opinion of City Solicitor on Underground Franchises.

THE peculiar relations existing between the various electric light and telephone companies, and the reasons for the high cost of the electric lights furnished to the city, are likely soon to have a little additional light thrown upon them. President Lawrence, at a recent meeting of city council's finance committee, promised to ventilate the latter subject. A deficiency in the appropriation for electric lighting was under consideration, and Mr. Lawrence drew from chief Walker the statements that the present contracts for the lighting would expire on January 1, and that the average price per lamp per night paid by the city is 55 cents. This was enough for the president of common council, and he remarked impressively:

> Then I desire to inform this committee and the citizens of Philadelphia that the city of York, Pa., pays for electric light 16 cents per lamp per night, the city of Columbia pays 18 cents, and the city of Lancaster 22 cents. I also desire to state that a Philadelphia company which is charging us 55 cents per night has offered to furnish the light for York for $7 per month per lamp. I do not propose to give one dollar more for lighting the streets of Philadelphia than is paid by these little inland towns. When this appropriation comes up in councils I will ventilate the subject.

Nearly all the companies which supply lamps for city lighting are in the Electric Trust. When this combination was formed last winter it was reported that it intended to put up prices on the city. This was not done at the time, owing to a strong protest, but it was said that the prices for 1888 would probably be advanced. If this shall be attempted some breezy developments may be expected.

The Penn Electric Light Co. maintains harmonious relations with the Trust. The two companies work in such perfect harmony that this may explain why no other electric light or underground companies can get any ordinances through city councils. The Keystone and Edison Electric Light companies have for a long time been applicants for franchises before councils, and their applications have been in the hands of a sub-committee of councils' electrical committee since June last. The Edison company, having recently made terms with the Penn Electric Light Co., is not now particularly anxious about any concessions from councils.

In this respect it differs from the Bell Telephone company, which has for a long time had an ordinance pending before councils, and has been desirous of pushing it through, that it might open streets and put its wires underground. It has been said that the Penn company is anxious that the telephone company should use its (the Penn company's) conduits for its wires, as this would insure a handsome revenue. The telephone company has replied that difficulties of electrical induction would make it almost impossible to use electric light and telephone wires in the same or adjoining conduits, and the matter hangs fire. Conferences have been held between the representatives of the two companies for several days past, and this astounding statement was made by a member of city councils yesterday: "An effort has been made to convince the Penn people that the Bell and Western Union companies cannot use the Penn conduits. If it should not prove successful there will be war and some fun."

The entire subject of the legality of the franchises held by the various underground conduit companies will be inquired into by the councils. The initiatory steps were taken December 6th, at a meeting of the law committee of councils. The sub-committee, to which had been referred in June last the resolution authorizing it "to investigate the legality of certain electrical ordinances passed by councils," made a report embodying the opinion of the city solicitor, which was read before common council a few days since. The sub-committee, through Mr. Scott and Mr. Anderson, reported the following as a substitute for the original resolution, which had been referred to it in June last, and requested that it be referred to councils with a favorable recommendation:

> Whereas the city solicitor has given an opinion, which is hereto annexed, from which it appears that all ordinances hitherto passed by these councils granting to others than corporations incorporated under the laws of the state of Pennsylvania, or who have not complied with the corporation laws of this state in regard to foreign corporations seeking to do business in Pennsylvania, permission to lay a line or lines of telegraph, telephone and electric light wires, construct and maintain electrical conductors, conduits, cables, manholes, etc., under the streets and highways of the city of Philadelphia are ultra vires and void; therefore be it
>
> *Resolved*, by the select and common councils of the city of Philadelphia, That the committee on law, by and with the advice and co-operation of the mayor and city solicitor, be and it is hereby authorized and directed to investigate and ascertain what ordinances are ultra vires, and to take such steps as will prevent the exercise of the powers granted in said ordinances, and such other steps as may be deemed necessary in the premises.

After some discussion the preamble was amended so as to make it refer to such companies as "have not complied with the corporation laws of the state in regard to foreign corporations seeking to do business in Philadelphia," When this had been incorporated in the resolution it was unanimously agreed to report it to councils with a favorable recommendation.

Chairman Etting will make his report to select council, and the first fight will take place in that chamber. Should it pass that body a most determined opposition will be made against it in the lower chamber, where the friends of the underground conduit companies are particularly strong.

The opinion of city solicitor Warwick, concerning the franchises of the Penn Electric Light Co., has given rise to considerable discussion among the stockholders of that corporation, the list of which includes many public men, politicians and well-known men about town. The stock is also held heavily by storekeepers along South street, who expected to reap a harvest by their investment. Most of these persons paid 75 cents and $1 per share for their stock. It is now held at 17 cents per share.

The opinion of the city's law officer was considered to be of so much importance that a special meeting of the directors of the Penn company was held to discuss the situation. Among those present were Messrs. James McManes, David H. Lane, tax receiver Henry Clay, George E. Vickers, and R. H. C. Hill, colonel B. K. Jamison, and professor Marks of the University were on hand as the representatives of the Edison company, and colonel Jamison was elected a director of the Penn company. It was decided that the council for the company should appear before the law committee of city councils and explain the legal status of that corporation. The Edison company is deeply interested in the subject, because it has spent over $200,000 in laying an iron pipe on top of the Penn company's wooden conduits.

The following is the opinion of city solicitor Warwick, referred to above :

I. Have the councils of the city of Philadelphia the power and legal right to grant to a corporation not incorporated under the laws of the state of Pennsylvania, or to a company, a firm or an individual, permission to lay, construct or maintain a line or lines of telegraph, telephone, electric light wires, electrical conductors, conduits, cables, manholes, pneumatic tubes or steam conductors under the streets or highways of the city of Philadelphia ?

To this I reply as follows: The streets of Philadelphia are under the control of the commonwealth. Any person or corporation claiming a right to occupy and use the streets of Philadelphia for the purposes and in the manner indicated in your question must show authority from the commonwealth. Unless this authority is shown, councils have no power nor legal right to grant permission to such individual or corporation to tear up the streets and lay down lines of telegraph, telephone or electric light wires, or perform any work contemplated in your question.

II. Have the councils of the city of Philadelphia the power and legal right to grant to a corporation not incorporated under the laws of the state of Pennsylvania, or to a company, a firm or an individual, permission to erect, construct or maintain a line or lines of telegraph, telephone, electric wires or poles upon the streets or highways of the city of Philadelphia ?

In answer to this inquiry I desire to say there may be some doubt in relation to the question as to how far a city can prevent the construction of a telegraph line, the same being considered an instrument of commerce (Pensacola Telegraph Company *vs.* Western Union Telegraph Company, 6 Otto, page 8 and others) But so far as the electric light wires or poles are concerned, the individual or corporation proposing to do the work must show authority from the state before permission can be granted by the councils of the city. Foreign corporations may become corporations of this state by complying with the requirements of the act of June 9, 1888.

III. Is there any act of the legislature of the state of Pennsylvania under which a charter can legally be obtained granting to a corporation so incorporated the right to lay, construct or maintain, subject to the consent of the councils of the city of Philadelphia, a line or lines of electrical conductors, conduits, cables, wires or tubes under the streets or highways of the city of Philadelphia, for the purpose of furnishing electric light or power to the public ?

In answer to this I would say that there is authority under sections 2 and 34 of the act of April 29, 1874, to obtain a charter for the purpose of furnishing electric light or power to the public by laying conduits, wires, etc., under the streets of the city, subject, of course, to the consent of councils.

The Penn Electric Light Co., which has been the subject of so much comment in city councils by reason of the city solicitor's opinion relative to the alleged legality of the company's franchise in this city, has a remarkable history. Its projectors have reaped a rich harvest off the public, and they have pocketed not less than $200,000. It has obtained from city councils franchises valued at $5,000,000. Its officers include such well-known persons as Messrs. James McManes and David H. Lane. The company has practical control of the streets of the city.

PHILADELPHIA, Dec. 18, 1887.

BOSTON.

Electric Lighting Notes.—Curious Result from Leaking Gas Mains.—Appeal of the Western Union Telegraph Co. against Taxes imposed by the Commonwealth.—The Boston Electric Club.—The American Bell Telephone Co.'s Output.—Report of the Erie Telephone Co.—The American Telephone & Telegraph Co.—Effectiveness of Safety Guards for Electric Wires.—Electric Street-Railway Notes.

THE stockholders of the Cambridge Electric Light Co, have voted to authorize the issue of $50,000 in bonds to run for five years, with interest at 6 per cent., payable semi-annually. It was voted that $30,000 of the amount be offered to the present stockholders. The meeting also authorized the directors to purchase a suitable site for a new location for the company's plant, owing to the settling of the foundation of the machinery where at present located.

One of the superintendents of the Boston Gas Light Co., while crossing Park square just as the day's business was beginning, on a recent morning, noticed a large sheet of flame coming from the top of the electric light post in the square. He at once had the gas shut off from that section, and an investigation showed that the large main of the Bay State Gas Co. was resting on a four-inch pipe of the old company, and the weight of the main had forced the pipe out of place and caused a bad leak. The gas, on escaping, had followed the line of the pipe to the electric light post—which stands where a lamp post formerly stood—and as the post is hollow, the gas rushed up through it and was ignited by the electric light. It is said that when the flame was discovered it was two feet wide and at least three feet high. The electric light fixtures were destroyed.

It is probable that by Jan. 1 the Westinghouse company will have its electric incandescent lights—1,200 or 1,300 of them—in operation in the Hoosac tunnel. Experiments have been made with satisfactory results over a half mile of the four miles traversed. The power will be furnished by the Fitchburg Railroad Co., either from the water-mills of the Deerfield river that were in use in constructing the tunnel, or by steam. The proposal to light the tunnel involves several novel problems in electrical engineering. Preliminary experiments made last summer showed that the gas and smoke exerted a powerful corrosive effect on the common electrical appliances. Chemical action, as well as perpetual dampness, has therefore to be contended against. The metal sockets usually employed with incandescent burners will not answer at all, and some other material must be employed. Extreme pains will also have to be taken with the connections between the main wires and those leading to the lamps.

Consolidation seems to be the order of the day in all the larger branches of business. The American Electric Manufacturing Co., of New York, has been in consultation with the Electrical Development and Manufacturing Co., of this city, and an arrangement was arrived at by which the entire factory, property and patents belonging to the Electrical Development company will be absorbed by the American company for stock in the latter company.

At a meeting of the Boston Electric Club last evening at its rooms, No. 66 Boylston street, the following-named officers were chosen:

President, P. H. Alexander; vice-presidents, William J. Denver, Suel Smith, E. Wilbur Rice, Jr., Frank Fuller; treasurer, F. J. Boynton; secretary, Robert F. Ross; historian, Allan V. Garratt; executive committee, Frank Ridlon, A. H. Chapman, C. M. Ransom, H. B. Cram, H. J. Pettengill, Edward Blake, Leopold Schlegelmilch, William Brophy, A. L. Rohrer, George W. Adams, Henry B. Lytle, J. T. Moriarty, S. E. Barton, W. I. Barker, Geo. W. Davenport, H. H. Eustis, H. N. Sweet, E. L. Caldwell. F. E. Clark, J. R. Lovejoy.

The annual dinner of the club will take place on Déc. 17th. On Monday evening, Dec. 19, Professor A. E. Dolbear will lecture before the club.

The output of telephones by the American Bell company for the month ended Nov. 20, and for the fiscal year to date, is stated as follows:

November—	1887.	1886.	Increase.
Gross output	4,330	3,340	990
Instruments returned	2,667	1,825	842
Net output	1,663	1,515	148
Dec. 21st to Nov. 20th—			
Gross output	48,670	38,360	10,310
Instruments returned	24,695	18,238	6,457
Net output	23,975	20,122	3,853

The Erie Telephone Co.'s earnings for October are reported, and maintain the substantial improvement heretofore shown. Full figures follow:

October—	1887.	1886.	Increase.
Gross earnings	$53,831	$46,015	$7,816
Gross expenses	32,284	32,132	152
Net earnings	$21,547	$13,883	$7,664
Construction	6,464	2,975	3,489
Surplus	$15,083	$10,908	$4,175
April 1st to Oct. 31st—	1887.	1886.	Increase.
Gross earnings	$354,041	$310,400	$43,641
Gross expenses	230,966	207,168	23,798
Net earnings	$123,075	$103,232	$19,843
Construction	27,470	17,232	10,238
Surplus	$95,605	$86,000	$9,605
Subscribers added—	1887.	1886.	Increase.
October	62	53	9
April 1st to Oct. 31st	639	407	232
Connected Nov. 1st	10,361	9,331	1,030

The American Telephone and Telegraph Co., that branch of the American Bell Telephone Co. which operates long-distance lines, will very soon be in condition to transact Eastern business. They have taken elegant offices at 53 Devonshire street, basement, which are in charge of Mr. Lewis, who has for an assistant Mr. J. H. Jefferson, late an employé in the American Bell general office.

The utility of safety-guards for electric wires received a demonstration recently in South Boston. A telephone line with six subscribers thereon—three of the six being provided with the Farnham safety wax-guards—was crossed with an electric light wire; the three without the guards were burned out. The absolute necessity of providing means of salvation is apparent.

On the 5th inst. another electric street car invaded the crowded streets of Boston, passing through the most busy part of Washington street just at the noon hour. The car was an old one of the Cambridge railroad, fitted up by the Weston Electric Light Co., under the immediate supervision of Col. C. H. Hewins, the company's general superintendent. The experiments which finally resulted in the trip of yesterday began as long ago as last March, when Col. Hewins obtained the use of the car. It was not until about three months had elapsed that the car made its appearance upon the streets, and from that time to this it has run over about all the routes of the Cambridge railroad. It derives its power from Julien storage batteries, the cells, 120 in number at present, occupying the spaces beneath the seats. At first there were only 104 cells, but when the West End's Sprague motor car made its appearance, the additional cells were put in to place it upon equal footing with the Sprague motor, in order to allow proper comparison to be made. The motor on this car is placed beneath the centre, and the power is transferred to the wheels by means of 10 wire belts running from the motor to a pulley on the axle. There is a mechanical arrangement which reduces the speed of the wheels very materially from that of the dynamo. The mode of controlling the movements of the car is by the use of a horizontal wheel, similar to the brake wheels on passenger cars. This wheel tops a stout rod on the car platform, so arranged that, at a moment's notice, it can be transferred to the other platform, leaving one platform entirely clear all the time. There is not even the rattling noise of the ordinary horse cars. Two sets of batteries will be required to operate a car each day, ten hours being required to charge each. The number of miles actually to be run by them, regardless of stops, has not yet been determined by Col. Hewins. Col. Hewins states that, from the first trip made by the car until the present time, it has always returned to its stable without the assistance of horses, and during that time it has climbed the worst grades on the Cambridge road, even accomplishing the very steep ascent of the Newton hill, rendered more difficult as it is by a considerable curve.

The trip was from Harvard square, up Cambridge street hill, through Court street, Cornhill, Washington street, Temple place, Tremont and Boylston streets, Park square, Church, Boylston, Charles and Cambridge streets, back to Harvard square. Cambridge hill was climbed easily, but the mud and slime on Washington street was too much for the car, until some sand was procured and placed upon the rails, when the car moved quietly onward.

The progress of the car was watched with interest by thousands of people upon the streets. It is the intention to soon place it in the regular traffic between Boston and Harvard square, and thus it will be given an opportunity of practically demonstrating its ability and its reliability.

It is thought that work on the Quincy street railway will be begun early next spring. The motive power, which will be electricity, will be furnished by dynamos run by two 50 h. p. engines. The current will be distributed over the route by an overhead copper wire. This wire will be about a quarter of an inch in diameter, and strung on arms projecting over the track, the arms being fastened to poles. The electricity is conveyed to the motor, which is in the front end of the car, by a wire, which is attached to two grooved composition wheels which run overhead on the main wire at the same speed the car travels over the track. The cars will look like the ordinary horse-cars, and will be lighted by electricity. It is expected that a speed of 15 miles an hour can be attained.

BOSTON, Dec. 16, 1887.

CHICAGO.

Mr. C. N. Fay leaves the Chicago Telephone Co. and accepts the Presidency of the Gas Trust.—Mr. B. E. Sunny also leaves the same Telephone Co. to become President of the Chicago Arc Light Co.—Mr. Geo. L. Phillips to be President and General Manager of the Chicago Telephone Co.; That Company's Franchise.—The City Council seeks State Intervention Against the Gas Trust.—A Fuel Gas Co. to Compete with the Gas Trust, using Incandescent Gas Burners: The Welsbach Incandescent Burner Attracting Attention.—Delay in Constructing the New Edison Light Station. The City Electric Light Plant Nearly Ready for Use.—The New Building of the Chicago Telephone Co.—The Chicago Arc Light and Power Co. to Consolidate Outlying Stations at one Point.—Some Features of the New Station.—The Westinghouse Electric Light Plant at Denver, Col.—The United States Electric Lighting Co. Installing Alternate Current Plants in the West.—Mr. J. Humbird Appointed Selling Agent by the Westinghouse Electric Co.—An Old St. Louis Gas Company to Take Up Electric Lighting. A Combination of Manufacturers to Defend the suit of the Brush Electric Co. against the Faraday Carbon Co., for infringement of patent on copper-plated Carbons; Other Litigation.—Mr. G. S. Ladd and Mr. J. C. Henderson, of San Francisco, in Chicago.—The Large Eastern Interests Represented by Them on the Pacific Coast.—Mr. K. Sawai, of Japan, Studying Practical Electrical Engineering in Chicago.—The Recent Rise in Price of Copper and Other Metals.—The Chicago Electric Club.

NO occurrences in electrical business this month have attracted more attention here than the resignation of Mr. C. N. Fay as general manager of the Chicago Telephone Co., to accept the position of president of the Gas Trust, at a salary, it is stated, of $20,000 per annum, and the resignation of Mr. B. E. Sunny as superintendent of the Chicago Telephone Co. to accept the presidency of the Chicago Arc Light and Power Co.

As president of the Gas Trust, which is very unpopular just now in Chicago, Mr. Fay will have abundant opportunity to use the ability which has won the position for him.

The Chicago Arc Light and Power Co. is practically a branch of the Gas Trust, the same stockholders controlling both organizations. Mr. Sunny's promotion is a source of gratification to his many friends. But it will be difficult to find a man who will fill so acceptably and so ably as Mr. Sunny the position which he leaves in the Chicago Telephone Co. The resignation of both gentlemen take effect January 1 next, and it is understood that Mr. George L. Phillips, now president of the Central Union Telephone Co., will become president and general manager of the Chicago Telephone Co.

The question of the validity of the franchise under which the Chicago Telephone Co. has been and is carrying on business was referred to the corporation counsel, Judge Green, who has rendered an opinion, in which he says that the Bell Telephone Co., to whom the original franchise was granted, had no power or authority under the terms of the franchise to assign it to the Chicago Telephone Co. The franchise is therefore void. But the city has done business with the present company in accordance with the terms and provisions of this franchise, and Judge Green is therefore of opinion that this fact may be regarded as constructive admission on the part of the city of the validity of the charter. Nevertheless, as these business arrangements have been almost entirely with the executive officers of the city, a doubt is expressed as to their action being in any way binding on the city.

The city council, finding the legal position of the Gas Trust strong enough to resist the attack of the municipal government, has called in the assistance of the state by requesting the attorney-general to bring *quo warranto* proceedings against the gas companies composing the Trust to compel a forfeiture of their charters. The attorney-general has signified his intention to commence such proceedings forthwith.

Another opposition to the Gas Trust has appeared in the shape of a company which proposes to use fuel gas with the Fahanjelm incandescent gas burner. The Welsbach incandescent gas burner also is attracting the attention of some capitalists, and will very likely come into extensive use unless the frailty of the mantle of refractory earthy material, which is the distinguishing feature of this burner, should prove here, as it has proved in some instances in Europe, such as to render it unfit for practical service.

The progress of the work of constructing the Edison electric light station has been delayed by various causes, one of which has been the changes in the details of the building which is in course of construction for this plant. These changes are found necessary to meet the requirements of the installation, which are new in many respects. The delay on the part of the manufacturers of iron beams also holds back the work, so that it now seems impossible that the plant should be in operation by the 1st of February.

The contractors for the construction of the city plant for lighting the bridges and viaducts say that their lights will be turned on by January 1st.

The handsome building of the Chicago Telephone Company is nearly completed. At least the walls are up and the roof is on, and the work of finishing the interior is progressing rapidly. The building will be ready for occupancy and the consolidated central office, with a multiple switch-board for 3,000 subscribers, will be ready for service by May 1st, 1888.

The Chicago Arc Light and Power Co. is making ready to move the dynamos, which now occupy various stations around town, into the grand central station at 76 Market street, where to begin with there will be 32 dynamos, of capacities ranging from 25 to 50 lights, all in operation. The Western Electric Co. is building the large switch-board for this station, after plans prepared by Messrs. Cushing and Brown, of the Chicago Arc Light and Power Co. It will have 160 spring jacks, with two auxiliary sockets to each jack, and all metal parts will be protected so as to avoid all danger to the attendant. There will be used in running the circuits from the switch-board to the sidewalk, where the lines enter the conduits, 15,000 feet of okonite wire.

The large Westinghouse plant of the Colorado Electric Co., in Denver, was recently started successfully. There is already a demand for more lights than the entire present capacity of the plant.

Notwithstanding the fact that the Westinghouse Electric Co.

has brought suit against the United States Electric Lighting Co. for alleged infringements of patents, the latter company is installing alternate current plants in various places in the west.

Mr. James Humbird, formerly of the firm of Humbird & Gorton, western agents of the Edison Electric Light Co., has been engaged by the Westinghouse Electric Co. as their general selling agent.

The old, rich and conservative Laclede Gas Co., of St. Louis, has decided to embark in the electric lighting business. Following is the statement of captain John P. Keiser, president of the company:

"We have been forced to do this by the increasing popularity of electricity as an illuminating means. A large number of our best patrons have discarded gas and substituted electricity for it, and in order to keep up with the times we have had to take measures to provide for the people who want light the kind of light that they prefer. Electricity is rapidly coming to be the light for streets. Detroit is lighted by electricity, so is New Orleans and so is Terre Haute. We expect that our electricity will be demanded most by business houses, and for lighting the streets. There will be little need of it in residences. We are now lighting 4,000 city lamps, and receiving $37 a year for each. When our contract expires we expect to have to bid against close competition of all kinds, and we will offer the city electricity, if it will have it, for all its streets. The charter of our company which allows us to use electricity as well as gas, also permits us to furnish the electric light to consumers in any part of the city. What the difference between the cost of street lighting by electricity and by gas will be, I can't say, nor am I prepared to state what system of electric lighting is likely to find most favor with the directory. We intend to get what we think is the best system, without regard to its cost. Then the company will be in the position it desires, prepared to compete with either gas or electric light companies for private or municipal business. This is about as far as we have got with our plans now."

In this movement the Laclede Gas Co. is falling into line with the very considerable number of gas companies in all parts of the country that are either operating or erecting electric light plants. The number of such companies is increasing very rapidly in all directions.

The suit brought by the Brush Electric Co. against the Faraday Carbon Co., for alleged infringement of the Brush patent on copper-plated carbons, will be defended by a combination of the manufacturers of carbons. Mr. Fish, of Boston, has been engaged to conduct the defense, so if the Brush Electric Co. expected to obtain a judgment by default in this case it will be disappointed.

The case of the Brush Electric Co. against the Fort Wayne Jenney Electric Light Co. was tried this month at Indianapolis. No decision has been rendered in this case. The patent in question is the one on the differential magnet.

Mr. G. S. Ladd and Mr. J. C. Henderson, respectively president and general manager of the Electrical Development Co., and of the Pacific Electrical Storage Co., spent some days in Chicago recently. The Electrical Development Co. is the agent on the Pacific coast of the Edison Electric Light Co. and the Western Electric Co. The Pacific Electrical Storage Co., which is a licensee of the Electrical Accumulator Co., of New York, is preparing to build a factory in San Francisco for the manufacture of accumulators, as the expense of transportation is so great as to make it inexpedient to have them carried from New York.

An interested and interesting attendant of the meetings of the Chicago Electric Club of late has been Mr. K. Sawai, now engaged in studying practical electricity and electrical apparatus in this country, after his theoretical training in the Japanese university, of which he is a graduate. Mr. Sawai shows much zeal in his pursuit of knowledge. He secured permission of the Western Electric Co. to enter their shops as a workman, and he is always at his post ready to perform any duty assigned to him. He intends to remain in this country for a year or two and then to spend some time in Europe before returning to Japan.

The recent large advance in the prices of metals, especially copper, zinc and tin, is watched with much interest by every one engaged in the manufacture or use of electrical apparatus. The feeling here is, that while prices, particularly of copper, may have been too low for some time back, the present enormous advance is going too far the other way; that present prices may last three months or a little more, but that the tendency will soon be downward, and in the spring will reach a more reasonable figure, and one that will be more satisfactory to the electrical interests of the country.

The Chicago Electric Club has held its usual two meetings this month. At the first Mr. C. K. Giles read a paper on magnetism in watches. At the last meeting a paper was read by George H. Bliss on automatic temperature regulation. The club is making arrangements for a banquet on the evening of January 7th, and as an evidence of the prosperity and stability of the club, which has now a membership of nearly two hundred, billiard tables will soon be added to the attractions of the club rooms.

CHICAGO, Dec. 24, 1887.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, *115 Nassau Street, New York city.*

MR. KINTNER'S EQUATION FOR A TELEPHONE CURRENT.

[83.]—In THE ELECTRICAL ENGINEER for December, Mr. C. J. Kintner gives a diagram and this equation for the currents produced by "a pure musical tone entirely free from harmonics," $c = \frac{vt}{d^2}$. If he is going to make further use of this equation, or if the further discussion has any connection with it, I should like to have some light upon it.

Mr. Kintner says "v may be assumed constant for any interval of time, since the power due to this particular sound-wave is a constant, so that the velocity tends to be of a constantly accelerated nature, but is, in fact, opposed by a constantly increasing power—the elastic stress of the diaphragm." If a pure musical tone without harmonics is maintained in a column of air resting on a diaphragm, the energy transmitted to the plate is not constant, even during the interval of the impinging of a single condensation. It is true that the energy of the molecules of each of the successive cross-sections is constant. But this constant energy is made up of two parts—a kinetic part due to velocity of the particles, and a potential part due to their displacement from equilibrium positions. Only one of these, the kinetic part, has any effect on the diaphragm. The action of the wave on the diaphragm must be of variable "power," instead of constant. But even if it were constant, can Mr. Kintner show that the elastic stress of a plate, clamped around its edges and under uniformly distributed pressure over the central region, increases in such a way that the velocities of its parts are constant under a constant accelerating force? Again, has he taken into account all the forces acting to give the diaphragm velocity? He mentions only wave energy and elastic stress. Does not the change of magnetic induction and field intensity, as *d* changes, affect the velocity?

"There is generated during the advance of the diaphragm a plus current of constantly increasing volume, until the value of *d* has diminished sufficiently to change its volume." I do not understand how diminishing the distance of the diaphragm is to decrease the volume of the current, especially with v constant. Is not the volume of current due directly to rate of change of magnetic force within the coil? And is not this rate of change of magnetic force some function of (*a*) the velocity of the diaphragm and (*b*) the magnetic field? Is not the diaphragm velocity a function of variable wave-energy, variable elastic stress, variable magnetic stress again varied by variation of current, and variable time? Is not the magnetic field, in form and intensity, some function of the physical conditions of the core and diaphragm, the variable current strength, and the variable distance?

I would offer the following, in place of Mr. Kintner's first equation:

$$c = \varphi\,(\text{velocity, field,})$$
$$= \varphi \left\{ \begin{array}{lll} \text{variable wave energy,} & \text{variable current,} & \\ \text{" elastic stress,} & \text{" distance,} & \\ \text{" magnetic "} & \text{etc.} & \\ \text{" time,} & & \end{array} \right\}$$

But I have no diagram of the volume of currents to offer until I have time to investigate some, and calculate others, of the final variables. I. THORNTON OSMOND.

State College, Pa., Dec. 9, 1887.

THE WESTINGHOUSE ALTERNATING SYSTEM.

[84.]—All the explanations heretofore published of the Westinghouse dynamo have been deceiving as to the number of reversals the machine gives, and I see that Mr. Addenbrooke, in an article in your paper for December, has gotten a false impression when he comments on the number of reversals being unnecessarily high.

The 650 and 1,300 light machines have a speed of 1,650 revolutions, but they have only 10 field magnets instead of 16, as I have seen it stated in a number of electrical papers. This would give 16,500 alternative 33,000 reversals per minute, instead of 40,800, as Mr. Addenbrooke is led to believe. AN OBSERVER.

Pittsburgh, Pa., Dec. 10, 1887.

ELECTRICAL NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

SPECIAL MEETINGS—DECEMBER, 1887.

MEETING OF DECEMBER 6.

The President, Mr. T. Commerford Martin called the meeting to order at 8 o'clock P. M. and said: The subject which we have before us this evening is one of the first importance. I therefore have much pleasure in asking Mr. William Stanley, Jr., the electrician of the Westinghouse Electric Co. to read us his paper on the "Phenomena of Retardation in the Induction Coil."

Mr. Stanley then read his paper. (See page 5.)

DISCUSSION.

Mr. Townsend Wolcott—I would like to ask Mr. Stanley if he has ever observed an effect in reversing the magnetism of the cores other than that of the Foucault currents, that is, a sort of magnetic friction; the mere reversal of polarity, independent of any induced current, producing an amount of energy. I do not know how much it is. I know that some years ago a French physicist experimented with alternating currents, using a copper core in one case and an iron core in another. Had the heating effect been due to the Foucault currents, the copper would have become much hotter than the iron, while in fact they did not get hot at all, while the iron became hot; so there was an effect due to the simple change of polarity—a sort of friction—it is analogous to friction. I would like to know how much effect that has in practice on the alternating systems.

Mr. Stanley—In measuring the loss in an induction coil we have found a very slight unaccountable waste, so slight, though, as to be almost immeasurable. It depends somewhat on the number of alternations that are driven through the coil. With about sixteen thousand alternations a minute the temperature of the coil, if it were placed in a calorimeter, would be indicated. The temperature of the calorimeter would indicate very nearly the amount of energy which was due to C^2 R, or the heating of the conductor itself. The iron of the core of the converter or the induction coil remains at a very low temperature indeed. Of course there is a considerable radiation while in the air. Mr. Shallenberger, in Pittsburgh, has made several careful measurements, and we are enabled to find that there is hardly any perceptible loss from magnetic friction. I can well say that with a very high degree of magnetization where the core was of a limited area in proportion to the number of ampere turns surrounding it, that there might be a considerable waste due to magnetic friction or magnetic saturation, and with the induction coils as made for the distribution of electricity for lighting purposes this is very small indeed. I cannot tell you its extent, but it is very small.

Mr. Howson called attention to the fact that a distinction had to be made between the true alternating current and the reversed or interrupted direct current.

Mr. Stanley remarked that for the purpose of distribution by means of transformers the interrupted or reversed direct current was of very little value, and said further: With your permission, I will endeavor to sift out this subject a little bit more. As I understand it, the effect of joining the magnetic circuit around the primary and secondary induction coil is practically to reduce the wire, if I remember correctly, to about one-sixth. In experimenting with coils, to begin with, I took Faraday's ring and wound a coil on either side. The best coil I have ever seen consisted of a bundle of perfectly straight wires on which was threaded a lot of iron washers. This has the highest counter induction per unit of length of any coil I have ever seen. In the Westinghouse company's system we get about two volts per foot of wire. This coil gave, if I remember correctly, about a volt to four inches. But it was impracticable to construct, as you could not make them fast enough. As I understand it the curves of electromotive force induced from an alternating current are these. A, B, C, D, E (see figure 5, p. 7), is a complete period of the curve of the primary or applied electromotive force. Now the induced electromotive force will be maximum at the time when the inductive effect of this primary current is a maximum; and the inductive effect of the primary current is a maximum when it changes from zero to any larger value. Consequently, the electromotive force of the induced current shown in the lower curve, figure 5, will be a maximum at this time; and it will be a minimum when the inductive effect of the primary is a maximum, and that will be when the rate of change of the primary is the least, viz., at the crest of the primary wave B and D, we find that the same values of applied and counter electromotive force are just one-fourth of the whole period of phase of the current. That is with an alternating current. In the direct current we never can have as great an electromotive force induced in the secondary circuit because our primary circuit never passes the zero line. The curve of induced electromotive force in the case of a broken, direct or interrupted direct current I think is this (figure 1). As will be seen, the induced current will be of negative sign, while the positive current is going to maximum; and the induced current will be of positive sign, while the applied current is falling from the maximum.

Perhaps it might be interesting to illustrate the applications of induction coils for covering long-distance distribution. It is well known that the cost of a conductor varies inversely as the square of the electromotive force. The cost of the conductor for transmitting a given amount of energy will be, for 100 volts E. M. F., we will say, x dollars, while for a 200 volts pressure the cost will be $\frac{x}{4}$ dollars. Therefore, the economy of the alternating system over others is directly as the square of the ratios of their electromotive forces. But in order to cover enormous distances and to make the system as broad as possible, I devised another plan which may or may not be new. We are to apply it in Berkshire county, Mass., to distribute from a station over six miles of territory with a loss of two per cent. We have 100 h. p. to distribute, and the potential of distribution is to be 4,000 volts. Our alternating current dynamo is of 1,000 volts. In order to get the electromotive force up to 4,000 volts we simply wind one coil of wire and attach our dynamo to intermediate terminals of that wire, distant apart one-fourth of the entire length (as shown in figure 2). That is, the length included between the terminals is one-fourth of the whole length of wires wound on the coil. There is no secondary circuit whatever. Of course, there is an induced electromotive force upon every turn of wire on that core of so many volts per turn. We apply our electromotive force of 1,000 volts at those points in order to get 4,000 volts between the outside terminals. When we carry our current at this enormous potential over to the place where we wish to distribute we simply attach another self-induction coil similar to the first. On one-fourth of its entire length we tap out another circuit. That reduces the potential from 4,000 volts to 1,000 volts again. The maximum efficiency of an auto-converter, or converter of one

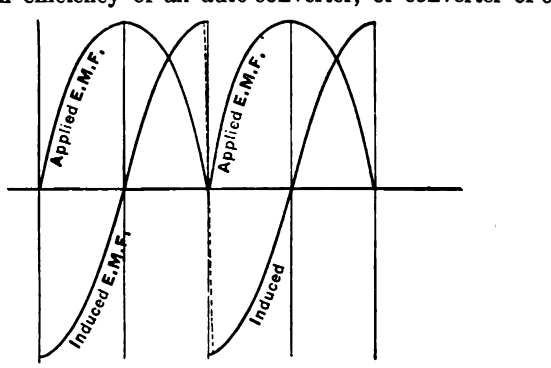


FIGURE 1.

coil evidently is found in the case where the ratio of reduction is from one to two, or two to one. If you have it in the ratio of one to four, or one to six, the saving is not nearly as great.

Mr. Prescott—I visited the station in the Berkshire hills a few days ago that Mr. Stanley speaks about, and I noticed that they had for the generators one omnibus wire running around the station such as are used in the Edison station. But this omnibus wire was split in two, and each generator worked into its own circuit. I asked the attendant why the omnibus wire was not connected across, and he said that if they connected it across they were likely to burn out their armatures. I would like to ask Mr. Stanley if that is so?

Mr. Stanley—That is so, through an oversight in the construction of the dynamos in the early stage of the business. We all have to learn some things; and the reason why it has been difficult to multiple-arc alternating dynamos is, that the phases have not been exactly the same. We make our dynamo pole-pieces of cast iron. Those cast iron pole-pieces did not measure to a thousandth of an inch the same width, and consequently the two phases of current, which ought to have coincided, did not coincide exactly, simply because of faulty construction. By tooling off and cutting the width of the pole-pieces to an exact measurement, there is not the slightest difficulty in multiple-arcing two, three or four alternating dynamos. I think a new feature in alternating currents, perhaps not well known to every one here, is the remarkable self-regulation of the alternating current machine. I cannot speak of it fully, because I have had very little to do with it. Another man is responsible for the beautiful work he has succeeded in getting. In Pittsburgh, a few days ago, I saw a 2,500-light dynamo run by a 250 h. p. engine, and 2,150 lights thrown by a single switch. The rise in electromotive force was one volt. I submit that in the present state of the art, it is impossible to construct a direct current machine which shall have anything like the self-regulation these alternating machines exhibit. The resistance at the commutator of a direct current machine would cause a greater variation of potential than was manifested in this machine I speak of. In the induction system we start out with an alternating current machine, in which we pretend to have at least a maximum loss of two volts in electromo-

tive force in the dynamo with the proper regulation necessary to any machine. Towns are wired, at least I know of two pole lines which are wired, for one per cent. loss of electromotive force, distributing electricity generally over an area of about a mile radius. The actual loss in the mains is one per cent. In the induction coil, at full load, there is another loss of two per cent.

Mr. Mailloux—I was expecting that somebody would refer to one of the features mentioned by Mr. Stanley this evening, which is to me one of the most interesting, from the theoretical as well as from the practical standpoint, inasmuch as it leads to a scope of applications. It is that system in which four lamps, A, B, C, D, were connected across the terminals of a constant potential alternating circuit; and in which the difference of potential for a particular lamp cut out was taken up by the self-induction coil (see figures 9 and 10, p. 8). Now I would like to ask Mr. Stanley whether the object of using that induction coil was merely to balance the other lamps, or whether it was expected that any energy would be saved by its use; in other words, whether the two lamps running with the circuit continued through the self-induction coil would require less current than would the four lamps.

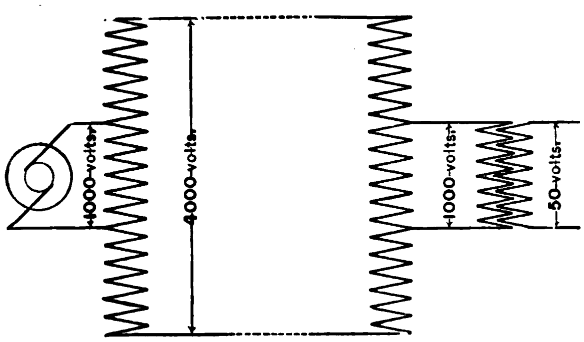


FIGURE 2.

Mr. Stanley—The connection of the lamps in series in that way was for a street-lighting system. In order to distribute lamps economically for street lighting purposes the plan adopted by Mr. Shallenberger was brought out. The shunted coil on the extinguishment of any one lamp prevents the rest of the lamps going out. For instance, there would be 20 lamps attached to a 1,000-volt circuit, each lamp of 50 volts. Now all those 20 lamps may go out, or 19 go out and the remaining lamp would be at approximate candle-power; and yet the sum of the electromotive forces, measured by a volt meter around the lamps and coils, is far in excess of the electromotive force that is applied to the outside terminals of the series

For instance (referring to figures 9 and 10, p. 8), there are four lamps connected in series. There was a lamp connected at *a*. That lamp is extinguished and in place of it there is a self-induction coil, *e*. This series is connected to a circuit whose voltage is 200 volts; a volt meter connected to each one of these lamps will show for the lamps *b*, *c*, *d*, 50 volts each, and for the self-induction coil, 100 volts. Now the sum of the interior electromotive forces here is 250 volts. The same volt meter will show an electromotive force of 200 volts on the outside terminals. That is, the sum of the interior electromotive forces is greater than the applied electromotive force. I think that can only be explained by the retardation of the current producing the average electromotive force.

Mr. Prescott—In regard to the point that Mr. Stanley kindly replied to a moment ago, I would say that it is of course well understood that if the time phases of any number of alternating current machines are identical there is nothing to prevent their being worked in a multiple arc. Now the question to my mind was whether there is any practical difficulty in getting those time phases the same. Of course that includes not simply the electrical and mechanical construction of the machine; it requires them to be identical in that respect. Now I have seen only two Westinghouse stations, and in both of them, each dynamo had a separate engine and in both cases the machines supplied separate circuits. Is there any case of any plant now in operation where a number of machines are successfully used in multiple arc?

Mr. Stanley—I think at Denver, Col., a station of 5,000 lights is run with dynamos in multiple arc, although I am not sure. The Pittsburgh station has been run in multiple arc. Our policy is not to run in multiple arc. We prefer not to. There is no choice in the matter excepting only that of simple expediency. We construct the station switch-board so as to connect any circuit leading from the station to any dynamo without causing a flicker in the lights, and thus give the dynamo a definite load that you can read on the amperemeters. That seems to us to be a very satisfactory way to run. As the evening grows later lights are cut off, the circuits are transferred from a number of dynamos to perhaps a smaller number, and eventually down to one dynamo, which runs all night.

The subject of multiple-arcing of the dynamos comes so near the question of running alternate current motors that it is the same question practically, and I feel, perhaps, justified, in explaining a little phenomenon in that. If you take two alternating current dynamos and couple them together, and start them up, one dynamo will fall into synchronism with the other. In order to have an alternating current motor, it is necessary to have a direct current through the field and an alternating current through the armature. In order to get a direct current through the field, you have got to have a commutator, which will produce the field current. This current in the field will rise from zero to a maximum value and fall again to zero value, but the armature currents will be above and below the zero value (as shown in figure 3). Now, notice, that at the time marked by the full vertical lines, there is no current flowing through the field, and there is no current flowing through the armature. If, then, we have an alternating current motor which is running with the exact speed and in conformity with the number of alternations of the dynamo which is applied to it, and have the phases of the two currents in exact synchronism, that is, with equal phases coming together at the same times, we will have absolutely no current in the field while there is no current in the armature of the motor. Now the commutation of the field may be outlined as shown where C C C indicate the commutator segments. There has been, until the motor arrived at synchronism, commutation at different points in the phases as at the dotted vertical lines. But when the motor runs at exactly the same speed as the alternating dynamo, there is no force then at work keeping the motor going. In other words, you can run an alternating current motor up to speed, but the minute it goes into absolute synchronism it will fall off again, and the consequence is that the alternating current motor will see-saw. There will be no power to continue its motion. Its speed will fall, and it will drop down to a lower number of alternations, but will rise up again.

Mr. Prescott—What is the effect if you have just enough work on to keep the speed down?

Mr. Stanley—Then it will never rise to synchronism.

Mr. E. W. Rice, Jr.—I would like to ask Mr. Stanley in reference to his last statement as to the motor, what percentage is the variation in speed?

Mr. Stanley—Of course an alternating current motor in synchronism and kept there, runs at exactly the same speed as the alternating current dynamo does. If the motor is impelled to synchronism and beyond it, it will go to perhaps double the synchronism. If the alternating current machine is run 16,000 alternations per minute, the alternating motor if it goes beyond that number, would never stop until it gets to 32,000 alternations. But the chief difficulty is that it does not develop any counter electromotive force under the conditions described, because it cannot develop a counter potential unless it has at all times a constant field charge. As the current falls to zero, of course, it cannot develop any counter electromotive force at that time. An alternating current motor has no efficiency of any consequence until it arrives at synchronism and becomes practically a dynamo running in opposition to the dynamo applied to it, at which time it has an enormously high efficiency with the most perfect self-regulation.

Mr. Rice—I hardly understand what Mr. Stanley means, in view of some experiments we tried recently. We had a self-exciting dynamo, and ran it in multiple arc with another self-exciting

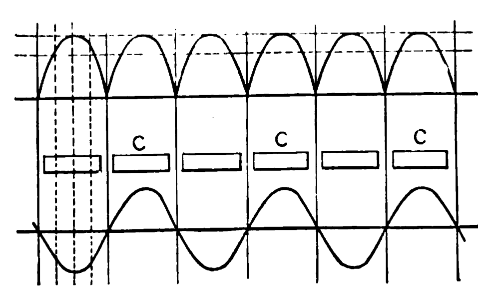


FIGURE 3.

dynamo, and then threw the belt off. The current from the generator proper passed from the armature of the motor. We did not find any variation to speak of, and it ran perfectly in synchronism. It was a generator capable of giving out about 25,000 watts. I then loaded it until the motor was giving out in the neighborhood of 50,000 or 60,000 watts without any change whatever in speed or any tendency to variation.

Mr. Stanley—It has an alternating field in which the magnetization periodically fell to zero. But in the dynamo the gentleman speaks of I understand the magnetization of the field was always the same. Consequently it was a true alternating current motor.

Mr. Rice—I do not see exactly how that meets the question, because the field of the motor was charged by itself, therefore it was falling from zero to zero again.

Mr. Stanley—The field of the motor was charged by a current developed by the motor itself on its own armature.

Mr. Rice—Yes, sir.

Mr. Stanley—And the phase of the current did not coincide with the phase of the applied electromotive force.

Mr. Rice—If I understand you for a certain period of time a motor running is exciting its own field. There was no opposition to the primary current from the generator.

Mr. Stanley—That is true. When the current in the field is zero, and the field charge is zero, then there is no electromotive force producible of course. But if the field charge is constant then it will develop a counter electromotive force and become a true motor.

Mr. Rice—I understand you to say that the field would fall to zero from the self-exciting motor.

The President—I would like to ask Mr. Rice if he is at liberty to give us a little information on the point of synchronism?

Mr. Rice—All that I can say in regard to that is that we have tried multiple-arcing dynamos. We have run dynamos together for a period of twenty hours continuously, and the loads seemed to be very equally divided, when the speed was kept uniform. We have also experimented with motors and found no difficulty in that direction.

I was very much interested in the system which Mr. Stanley attributes to Mr. Shallenberger. I think it is only just to Professor Elihu Thomson to say that that system was patented by him three or four years ago. He used almost identically that same arrangement which consisted of placing a self-inductive coil in place of a lamp, so adjusted that it would take just the current of the lamp. I do not know that that was the first time it was done, but so far as I know it was.

In reference to figure 4 (see p. 7), I do not know that I correctly understand Mr. Stanley's explanation of it. The diagram, I understand Mr. Stanley to say, applied to a coil in which there were iron cores. Is that true?

Mr. Stanley—Yes, sir.

Mr. Rice—And you say that the self-induction follows exactly the primary. Now it seems to me that coils with iron or without iron are the same excepting a difference in degree; there is no difference in kind. In that case it seems to me there would be a slight shifting.

Mr. Stanley—The difference in ratio is only one thirty-thousandth, and it being so small I thought it was not worth while expressing it.

Mr. Wheeler—I would like to ask Mr. Stanley whether there are any losses on the line wire other than that due to resistance—whether there is any current dissipated by retardation, self-induction, or anything of that sort?

Mr. Stanley—I was perhaps the worst frightened of any man who ever stood on solid ground when I read Professor Hughes' lecture on self-induction. But the effect of self-induction which he described, and the measurements on which it was based, were made with a broken direct current. With the system that we use we have been able to find hardly any variation from the true Ohm's law, and all our wiring details are based on the assumption that the resistance is the ohmic resistance of the copper only. In the case where the wire goes around an iron core it is not necessary that there should be a loss of electromotive force. The electromotive force is merely retarded for a moment, and as soon as it has fallen to a value below that of the charged magnetism, the stored electromotive force is all returned to the circuit. I think there is nothing so generally misunderstood as the loss of electromotive force in iron cores.

Mr. Wheeler—It is a case of magnetic storage.

Mr. Mailloux—I do not think Mr. Stanley exactly answered my question, and the remarks made bring us back to it again. The question is whether in that circuit that he speaks of in which an induction coil is substituted for a lamp, whether the loss of energy, in other words, the expenditure of energy, across that line is different in the second case from what it would be before that induction coil had been substituted. If, as Mr. Stanley argues, the effect of self-induction is simply to retard the electromotive force, then evidently we still have electromotive force there, and if it does not absorb electromotive force or cause no loss, then we should take less energy than would be accounted for by that which would be absorbed in the three lamps, plus that absorbed in the ohmic resistance, as he calls it, of the self-induction coil. For we must remember that the amount of energy required at the terminals of the induction coil is not as much as would be represented by C^2R. It is C R, plus a certain quantity which represents the work done in the induction coil in overcoming the counter-electromotive force of the coil. Now, then, it is interesting for us to know whether in that case the expenditure of energy was the same whether the induction coil was on or whether the four lamps were burning at one time. I incline to the opinion that it must have been the same, and that consequently there must have been a certain amount of work which was absorbed and dissipated by the self-induction coil.

Mr. Stanley—The energy on the lamp is exactly the same. If it were not the lamps would grow brighter. The potential on them is constant. The current going through them remains constant or they would not be of the same brilliancy. The self-induction coil does waste some energy, but it has the effect of storing energy for a brief interval of time and then returning it upon the circuit. As to the invention of the self-induction coil for this purpose, I have the very highest regard for Professor Thomson and always had, but if I remember correctly, the patent that Mr. Rice refers to is not for this purpose. It is for cutting in a coil. This is a very different invention. This is a coil always in circuit to do this work, while the coil Professor Thomson devised is cut into the circuit.

Mr Mailloux—I would like to state then that my conviction appears to be upheld by Mr. Stanley, that, the energy being the same, this induction coil represents nothing more than resistance. It takes up a certain amount of energy which a certain idle resistance would clearly absorb. If we were to replace that self-induction coil by another one having no self-induction, but a larger resistance, so that the circuit going into that resistance would absorb the same number of watts, then we would evidently have the same energy absorbed as we have by that induction coil. So that I do not see the induction coil in question does anything more than to replace a lamp that is put into that circuit. The case is exactly analogous to that of an electric motor that would be placed in circuit. The amount of energy absorbed by an electric motor is the difference of potential at its terminals.

Mr. Wetzler—It occurs to me that perhaps this phenomenon might be due to an error, or a peculiarity, of the measuring instrument employed. Mr. Stanley said that he employed a Cardew voltmeter. I would like to know whether he ever applied the electro-dynamometer for that purpose.

Mr. Stanley—The electro-dynamometer is a very unfortunate instrument to use with an alternating current, as its reading is changed by a slight fluctuation in the alternations. The Cardew voltmeter, which is dependent on the amount of heat produced, is entirely independent of the alternations. Perhaps I can explain that. The coil is acting exactly as a dynamo would act in series and it chokes down the current in direct proportion as the resistance in this part of the circuit is raised. The average electromotive force at the terminals of the coil, however, is greater than would seem to be warranted by Ohm's law.

Mr. Howell—Mr. Stanley said that inasmuch as the current was constant (as shown by the lamps) that is, the current in three lamps was the same as the current in four and that the electromotive force acting on the circuit was also constant, that the energy was constant in the circuit. I would infer then that C E is the measure of energy in the alternating current. Is that a correct conclusion?

Mr. Stanley—No, sir; that was a slip of the tongue perhaps on my part; but it is a most unreliable quantity. The energy of three is the same as the energy on the three lamps before. I think in reality there is very little waste of energy, But there is an apparent amount of energy wasted there—that is C E of coil. This is apparently as much as the energy expended on the lamp.

Mr. Howell—I think that that diagram is a very good illustration of the fact that C E is not a measure of the energy in alternating circuit, because you have only a value for C there, and the value of the energy in that circuit would be $C \times 200$. Now that is the sum of the energies in three lamps and the coil, and in each lamp it would be $C \times 50$, and in the other it would be $C \times 100$; so that the sum of these energies is not the same as the sum of the whole circuit computed the other way, which shows C E is not the measure of the energy in the circuit.

I would like Mr. Stanley to demonstrate why the current in the secondary increases, or why an increase of current in the secondary increases the current in the primary.

Mr. Stanley—I think that it is very easy to understand from the diagram (see figure 7, p. 8) of the counter-electromotive force, providing no current is flowing through the coil. The secondary electromotive force will of itself induce another electromotive force, and so we might go on inducing forever electromotive force. We cannot merely transform energy once; we can transform it a thousand times. Now the secondary electromotive force will develop a counter-electromotive force on the primary circuit, and that will be still one-quarter of a period later. Notice that I have drawn these curves directly opposite. It exactly opposes the primary electromotive force at the same instant of time. Now, when the current is abstracted from the coil, this is no longer the position of the secondary electromotive force; it is shifted on. Consequently, the counter-electromotive force no longer opposes the primary electromotive force at the maximum time of the primary electromotive force, and consequently its value as a counter or opposing E. M. F. is very much lessened. You have asked me a difficult question.

Mr. Wheeler—I would like to return to the three lamps in the induction coil, because I want to ask this question. Mr. Stanley stated, if connections were made between the main conductors we would have 200 volts; in figure 5, the terminals of coil *e* would measure 100 volts, and *f g h* would measure 50 volts, making a total of 250. Now I would like to ask Mr. Stanley what he would get if he measured the potential between the + conductor and the right-hand terminal of lamp *b*.

Mr. Stanley—I have never tried it.

Dr. Vander Weyde, at the close of the discussion described some of his early experiments with the induction coil, and exhibited a number of early models, in which attempts are made to completely close the magnetic circuit of the coil. One of these, figure 8, was made with long wires for the core, which wires were then bent over the sides and completely inclosed the coil.

MEETING OF DECEMBER 20.

Mr. T. C. Martin, President, said—I am very glad that, in spite of the inclemency of the weather, we have so large an attendance this evening of those who are genuinely interested in the question of patent reform. The subject of a revision of the patent law will be brought before us this evening by Mr. Arthur Steuart, who is the general legal counsel of the National Electric Light Association. The subject is one, I may say, that lies well within the province of the Institute of Electrical Engineers. It has been brought before us on various occasions, and it is somewhat interesting to recall that at our very first meeting, held in this room, for purposes of organization, now close upon four years ago, almost the first question that was introduced to our notice was that of patent reform; when Mr. C. J. Kintner of the Patent Office presented a spirited appeal to us for aid in bringing about certain reforms which he then deemed necessary. Since that time we have had valuable and forcible papers presented before the Institute by Mr. Frankland Jannus and by Mr. A. C. Fowler, both of whom brought out very ably the necessities of the situation at the time. It will thus be seen that the Institute is well prepared to consider the subject in all its bearings and relations, and is ready to learn from Mr. Steuart just what work the National Electric Light Association now proposes to do with regard to the bill to be introduced before Congress. I may say here that I have myself had the opportunity of attending all the meetings of the National Electric Light Association at which this question has been brought forward, and I think I may take the liberty of saying that that society does not intend to act with any undue haste or precipitancy in the matter, but is likely, in fact is sure, to move with its accustomed practicality and business-like common sense. Our position to-night is one in which we may be able to do great good in the direction of showing how far this movement is calculated to receive support and sympathy in scientific and professional circles, especially in those that are connected with electrical interests. I have much pleasure, therefore, in asking Mr. Arthur Steuart to read us his paper on revision of the patent law.

Mr. Steuart then read his paper. (See page 9)

The President—Mr. Steuart's weighty paper is now before us for discussion. On such an occasion as this, when there are so many views to be represented, we shall be very glad to have the participation in the discussion, of gentlemen who are interested, but who may not be members of the Institute; and before we proceed further, I think I express the general wish when I call upon Mr. George Ticknor Curtis to open the discussion. Mr. Curtis is known to all of us as a foremost student and exponent of patent law in this country, and it would be of the greatest usefulness to us all to learn from him what are his views of the subject in general, and what are the specific points to which he considers it best for us to direct our attention in seeking any reform of the system.

Mr. George Ticknor Curtis—Mr. Chairman, I have listened with the greatest interest to the very able and comprehensive paper which has been read. It is a subject that has occupied my thoughts and exertions for a good many years. A year ago last winter I caused to be introduced into the House of Representatives a bill, which I drew, for the appointment of a commission having the same general object and purpose as the bill which you contemplate. The especial features were a little different. I did it on my own responsibility, but I did not do it without consulting others. I consulted the Commissioner of Patents. I consulted one or two of the Judges of the Supreme Court of the United States, and other persons. The bill was referred to the House Committee, and they gave a hearing on it to me and other gentlemen. The Commissioner of Patents attended, and he urged more especially in regard to his own department the importance of the bill, and had a great deal to say, especially on the subject of the establishment within the Patent Office of a special tribunal, such as has been sketched in the paper that has been read this evening. The bill met with great favor with the House Committee, and they unanimously voted it, after making some modifications in a few of its details. They changed some of the provisions in respect to the compensation of the Commissioner and provided a suitable compensation for a secretary, and they made a distinct appropriation, I think of the sum of $40,000, to cover the entire expense. The bill was reported in the House, but it was overslaughed with thousands of other bills that never passed that Congress. I happened that winter to have a good many cases before the Committee, as counsel or associate counsel, and I became very intimately acquainted with the different members of the Committee from different parts of the country, and I am persuaded that if this association and the National Electric Light Association shall take up this subject and resolutely carry it before Congress in the mode in which you contemplate, that you can get the bill passed. That bill in which I had some instrumentality fell to the ground of course at the expiration of that Congress. I had a conversation with Senator Platt, of Connecticut, who is the chairman of the Senate Committee on Patents, and he raised this objection, that however good a code or bill might be prepared by such a commission, that when it came to be enacted in Congress, it would be loaded down with amendments that would kill it. Well, my answer to that was, that would depend on the ability of the Commissioners to make a consistent and harmonious code and one that would address itself, on its own merits, to the general legislative mind; and that it would also depend upon the ability of the Commission to explain the changes which they contemplated, or the improvements which they contemplated, in a report to accompany the bill; and I thought that if that could be done a majority of both houses would see the wisdom of passing it as it was presented by the Commission, and not undertaking to amend it, but let it go into operation and be amended as the progress of time should show amendments to be necessary. This matter was never before the Senate Committee. This was simply an informal and private conversation which I had with the Chairman. Now, sir, it would take me half the night to touch all the points, or half of them, on which it seems to me the time has come for this kind of action. My situation and occupation of late years have led me to bestow a great deal of attention on the course of the Supreme Court in the administration of the patent law. Unfortunately—I do not know how it has come about, exactly—but the present court has gone to very great lengths in overturning all the great doctrines of the patent law that were settled forty years ago when I first began to practice—and that is more than forty years ago. There have been decisions, which of course must stand as the law until Congress shall interfere and declare the law otherwise. Well, that is one great part of the task which such a Commission would have to perform. They would have to examine all these cases and see whether they are or are not consistent with the fundamental principles of the law as it has been construed heretofore. The statute law is substantially the same to-day as it was when enacted in 1838. There has not been any very material change. But there is a very great departure in the doctrines that are held now by the Judges of the Supreme Court from what seemed to me to be the sound and true doctrines of the law, and I hope you gentlemen will go ahead and get your bill passed and then secure as suitable a commission as you can. I have a copy of the bill of the last session, which I will hand to the President. I suppose that your bill, which in some respects is a better one, will go at once to the House Committee, and of all suggestions I should respectfully recommend that you avoid the appearance of aiming at any particular point, any particular change, in the present system of patent law more than others. The paper goes over a great deal of ground, specifies a great many different points. Well, there would be a difference of opinion, of course, about those different matters. In a great deal of it I agree. I do not know whether I should agree with every part of it, but if you can present your application in such a way as not to allow the Committee to have the idea that you have any axe to grind for yourselves or anybody else, in respect to any specific question, why I think there is no doubt but that you will succeed in carrying the measure that you wish to.

The President—It has been very interesting indeed to have these remarks from a gentleman so well known and whose experience extends over a period of well-nigh half a century. In listening to such mature advice and in governing ourselves by it, we certainly cannot go very far amiss. Mr. Curtis in his remarks made allusion to an interview that he had had with Senator Platt. I may state that a few days ago I wrote to Senator Platt, calling his attention to this movement which had been set on foot by the National Electric Light Association and which we proposed to bring within our purview, and I asked his opinion of it, saying that we would be very glad if possible to have his attendance at the meeting. I would like to read his reply. It is as follows:

U. S. SENATE, Washington, Dec. 17, 1887.

T. C. Martin, Esq., Prest. Am. Inst. Elect. Engrs., New York:

Dear Sir—I have your letter of the 15th, expressing your desire that I be present at your meeting next Tuesday evening in New York. It will be impossible for me to leave Washington at that time.

With regard to the proposed revision or amendment of our patent law, I can only say, generally, that while I think some amendments are very desirable, it is very doubtful, first, whether such amendments as are desirable can be obtained at the hands of Congress; and, second, whether any attempt to radically amend our patent laws would not result in the passage of laws calculated to injure the interests of inventors and the public. I say this, because my observation leads me to believe that probably two-thirds of the Members of Congress are more or less prejudiced against patents and against certain desirable features of the patent system, and during all my experience in the Senate it has been my effort to prevent Congress from passing laws which would be disastrous. No man can predict the outcome of an effort to amend the patent law. It may result in what we deem the advantage of the public. It is quite as likely to result injuriously to the public. I have been made to feel very many times that perhaps it was "better to bear the ills we have than to fly to others we know not of." In saying this I do not mean to imply that I am not in favor of amendments, but simply to indicate the danger that always confronts us when we attempt to legislate with reference to patents. Very truly yours,

(Signed) O. H. PLATT.

We have a representative of Connecticut with us in person this evening. I refer to Mr. Albert H. Walker, and his views on this subject would be likely to interest us very greatly.

Mr. Albert H. Walker—Mr. Chairman and Gentlemen—I have listened with great pleasure, as we all have, to him whom we regard as the father of us all, speaking of those of us who are patent lawyers, or are interested in the development of the useful arts. The pamphlet that I see in the hands of some of you, and which I suppose has been read by most of you, contains an article by myself which sets forth the principal part of my views touching the desirability of revising the patent laws. It will therefore not be expected that I shall elaborate my opinions upon the subject on this occasion; but I shall be glad, with your permission, to make some observations touching the expediency of pressing the bill to revise the patent system. I do not agree in the slightest with Senator Platt. My experience in the attempts that have been made to secure from Congress the revision of the patent laws, dates to a considerable earlier period than that of Senator Platt, and with all deference to him, I think it has been more extensive than his has been, because during his occupancy of a seat in the Senate no such effort of any degree of seriousness has ever been made. Ten years ago now the celebrated bill 300 was before Congress—the 45th Congress. Its herald, its John the Baptist, its forerunner, was before Congress 11 years ago—the 44th Congress—and very strenuous effort was made to pass that bill. Very large amounts of money were expended in employing distinguished lawyers to go to Congress and secure the passage of the bill. It was not at all favorable to the patent system as a science. It was advocated by men who had axes to grind. It was advocated by men of very great ability who had clients who contemplated plucking certain prospective prey of theirs, and it failed, because it was a bad bill, and I think that a bad bill can be relied upon to fail in the American Congress, upon the subject of the patent laws. A great many have failed, and I think they all will fail. Why?—Because there are so many intelligent men in Congress, and because there are so many intelligent men in the United States who can explain things to the intelligent men who are in Congress. If we are ever going to make an effort to secure a revision of the patent laws, no time is more opportune than this. I read this afternoon, on my way here from Hartford, an editorial published in the December number of THE ELECTRICAL ENGINEER, taking the view of this subject which is taken by Senator Platt in his letter. The Senator indicated in that letter his opinion that a Congress which sits pending a presidential campaign and pending the counting of an electoral vote, is a very inopportune Congress to which to apply for a revision of the patent laws. But half of our Congresses come within that category. Half of your Congresses sit in the last half of a presidential administration, and the other half in the first half of a presidential administration, and those Congresses which sit in the last half of presidential administrations are generally understood to attend chiefly to presidential elections rather than to the public business; and for that reason the editor of THE ELECTRICAL ENGINEER expressed the opinion that it is hopeless to expect anything in the way of important legislation from that Congress. I am inclined to agree with him, and therefore I advocate that that Congress be the Congress that be invited to pass the bill providing for a commission, and that the 51st Congress, which will not be trammeled by such considerations, be the Congress that be invited to enact the bill which shall be recommended by that commission. It is impracticable, in my judgment, to secure from any one Congress the passage of the bill to appoint a commission, and also the enactment of the legislation which may be recommended by that commission, because the time which passes after a particular Congress assembles and begins business before that Congress adjourns is less than fourteen months, and that time is too short a time in which to secure the passage of our bill or of any bill for the appointment of a commission, and for that commission to pass through its deliberations and produce its report and have Congress to intelligently act upon the bill which may be recommended by that commission. In point of fact those three things never will be done in any one Congress. Therefore the obvious plan is to ask one Congress to appoint a commission or provide for the bill appointing a commission, and the succeeding Congress to pass upon the legislation that may be proposed by that commission, and that is the scheme of the bill which appears in your pamphlets as having been advocated by the National Electrical Light Association. That bill is proposed to be introduced into the 50th Congress, and the report of the commission is proposed to be submitted to the 51st Congress, so that no time more opportune than the present will ever occur for us to move in this matter. Senator Platt has suggested the inexpediency of a commission, holding it more expedient to apply to Congress to pass particular legislation on the subject. That plan is far more likely to do harm than to do good, because such a particular bill to amend the patent law in a particular way is the very sort of a bill that will be loaded down by amendments. It will come before Congress with no responsible authorship back of it. It will be an anonymous bill. It will rest under the suspicion of having been gotten up by men with private interests to serve. It will be presented to the committees in Congress, and the committees in Congress will not understand the subject, and they will think they can improve this bill, and they will take a whack at it and put on a patch here and cut out a piece there, and finally when that bill is presented to Congress it will resemble nothing "in the heavens above, or in the earth beneath, or in the waters under the earth," and after it has been amended by the individual members it will bear a still less resemblance to any of the works of nature or true art; whereas a bill presented by a responsible, authoritative, respectable commission will have weight. It will remedy grievances which are justly complained of by those who are somewhat prejudiced against the patent system, as well as remedy evils under which those labor who represent the interests of inventors. These bills that have been introduced for the purpose of striking a blow at the patent system during the past five, six or eight years, have all been of one character. I have closely watched them. They are bills which provide that no suit for infringement shall be sustained against anybody for merely using a patented article which he purchased without actual knowledge that it was covered by a patent. These terrible grangers from the west that are represented as being willing to come down on the patent system the moment they are let loose, like the angel of death, have never made any attempts more extreme than that, and they have made their attempts a little more extreme than they would have made them if they were instructed on the subject a little better. They had a grievance on that point, and that grievance has chiefly grown out of the driven-well patent. But that grievance has been removed since the late decision of the Supreme Court on the subject. Mr. Andrews appointed agents to travel hither and thither through the western states and pounce on farmers who hired well drivers to put down wells, in total ignorance of the existence of the patent, and for which they demanded of them that they pay exorbitant royalty and had brought suits promptly against them, and then had added to the original amount a considerable sum for counsel fees and marshal fees, and what not, until the farmer had concluded he would have to mortgage his farm to get rid of that driven-well agent. That has stirred up a good deal of odium in some parts of the west, and members of Congress have thought they were serving their constituents splendidly by introducing bills providing that nobody shall be held liable for the use of a patented article that he purchased for himself without knowledge that it was covered by a patent. Now those bills have been too broad and sweeping. They could not be scientifically introduced into the patent laws without working inharmonious results, and those results were not foreseen by the men who advocated them. Now I believe firmly that if an intelligent commission had this matter in hand, one of the things that commission would do would be to draft a measure upon that topic, going as far as the just requirements of the grangers would carry them, and not going as far as the representatives of the grangers in courts have gone, and that those sections thus drafted would meet that ground of complaint and would be seen to meet that ground of complaint by the very men who have made the complaint. Now I have heard considerable ever since I attended before committees of Congress ten years ago, about a great deal of opposition to the patent system. This opposition to the patent system is like the fever-and-ague you had out west—it was never in the particular town you were in, but you could always find it in the next town. Now it has happened to me to draw the pleadings, or otherwise participate in patent litigation in every state of the Union, except five, and to argue cases orally in fourteen of the states of the Union, and I have lived among a wide variety of people. When I was a small boy my father took me from my New England birth-place to Wisconsin, into a purely agricultural community, a newly-settled country, where the painted Indians used to whoop by our house in the summer-time, and where there were no manufacturing interests, and I say to you gentlemen that I never yet met a solitary man in my life who was opposed to the fundamental principles of the patent system—not one individual. I have met the wild, untutored Congressman from Texas and from the western states, and I have met all classes and conditions of men from Massachusetts to California, and I have yet to see the adult voter who was opposed to the underlying principles and general framework of the patent laws. It is all imaginary. I have talked with Senator Platt about it, and Senator Platt has always adopted this mode of operation. If we get a bill sent up from the Senate to the House on the subject of the patent laws, throttle it, pay no attention to it, smother it in committee! That is the way he has done business. He has been in Congress at the head of the Committee on Patents. We have not had a solitary line of legislation, good, bad or indifferent, on the subject of patent laws, since 1875, and since 1879 there has been no serious attempt to remedy the evils under which the inventors of America have labored. This is a great wrong, and the United States Senators and Members of Congress have much to answer for. So that I see nothing to fear whatever from the appointment of a commission, but everything to hope from it, and I firmly believe that if a commission was appointed the head of which might be my own predecessor as a writer of patent law text-books, Mr. Curtis—if such a commission were appointed to sit as judges, to do justice according to their knowledge of patent law, between different classes

and conditions of men, between the inventors and the users of patents, the report of that commission would be seen to be so eminently fair, so eminently sound, that it would go through both Houses of Congress without serious opposition, without any attempts at amendment that would be more harmful than a fly upon the trunk of an elephant, and without any changes whatever. Whereas if we continue to content ourselves, or endeavor to content ourselves, with the outgrown clothes that we have tried to robe ourselves in during the past fifteen or twenty years, we will stumble along after a fashion, and the world will not collide with any other planet, and inventors will get some sort of reward for their inventions; but there will be a great deal of trouble, a great deal of unnecessary loss, and a great deal that ought to be avoided. In these days, when the arts are being so perfected, it is disgraceful to the United States that the patent laws are not also being perfected. What would anybody think of the suggestion to do away with dynamos by reason of the fact that they were more dangerous than a Morse telegraph sounder? In like manner, how can we estimate our courage at a high rate when we are at all restrained by the opinion of Senator Platt, or anybody else who entertains such an opinion, from doing what in us lies to bring to the attention of the American Congress the evils under which we and those we represent have long labored, and ask that those evils be remedied?

Mr. Curtis—Mr. Chairman, I may give my friend from Connecticut a single instance such as he never met with. A great many years ago—before the war—there was a Senator in Congress, from North Carolina, Mr. Badger. He was a very eminent lawyer—general lawyer—and a most admirable person. I was conversing with him one day about a bill that was before Congress,—I do not recollect whether it was a special bill or what—but it had relation to some changes in the patent law. Well, he said, all I know about the patent law is this :—some infernal Yankee comes down to my country and mouses around my back yard and looks over the fence, and he sees something in use there in my garden, and he calls out to me and says "Stranger, I have got a patent on that; you will have to pay me ten dollars for the privilege of using it." That, he said, is all I know about the patent law, and all I want to know. Well, I said, Senator, you are here to legislate for the people of the United States; you are in the highest branch of the legislative department; now that is not worthy of you or of the state that you represent. Now, you just take this subject and look into it and you will find that there is a great deal in it that you ought to know and that you ought to be able to give an intelligent vote upon. He did so, and he was entirely convinced that he ought to know something more about the subject than he did. That is the only instance of the kind that I have met with.

Mr. G. M. Phelps, Jr.—Mr. Chairman, I have a letter here from Mr. Kintner, which I will ask the Secretary to read, and after he has read it I will have a word or two to say.

The Secretary then read the following letter :—

265 Broadway, Rooms 26 and 27,
New York, Dec. 17, 1887.

Mr. George M. Phelps, Jr.,
11 Wall Street, City.

My Dear Sir:

I am in receipt of a communication from Mr. R. W. Pope, Secretary of the Institute of Electrical Engineers, advising me of the discussion touching the question of a revision of the patent laws on the 20th inst., and inviting me to be present and express my views in relation thereto. I had hoped that it would be possible for me to be with you upon this most interesting occasion, but business engagements will keep me in Washington the greater part of next week. This matter is of momentous interest to all inventors and persons interested in patent property.

Some years ago I had the honor to call the attention of the Institute to the wants of the Patent Office and the necessities of material changes in the patent law. I have noted with interest all that has been done by the society, and am gratified at the fact that the committee appointed has succeeded in putting matters in a tangible shape to go before Congress. While the scheme proposed by this committee is, in my opinion, entirely practicable, I have some hesitancy as to the feasibility of its presentation to Congress at this time, and am in hearty accord with the views expressed by you in your editorial in the December number of the Electrical Engineer.

During my official connection with the Patent Office as its chief clerk, I very naturally became pretty well versed with the political phases of all matters appertaining to the conduct of the bureau. It is needless for me to say here, that in matters of politics individual personal interests control individual members of Congress, and that upon the eve of a great national election such as occurs next November, we cannot afford to run the risk of losing everything in a proposed change of existing laws. I therefore beg that you will present the following resolution to the Institute and urge its passage :—

Resolved, That it is the sense of this society, that it is unwise at this time to seek by legislation to in any way modify the existing patent system, and that any movement to that end should be postponed until after November 1st, 1888.

I am sure that this resolution will meet with the full approval of every one who has the good of the patent system at heart.

Very respectfully yours,
C. J. Kintner.

Mr. Phelps—Mr. Chairman—I present the letter at this time because Mr. Kintner supplies a resolution and has requested that it be offered, and I offer it and move its adoption, in order to have a more definite thing before us to discuss. I have listened with great interest to Mr. Curtis and to Mr. Walker, but I am still of the opinion that it would be unwise to present the proposed bill to Congress. I think it is quite clear that there is no difference of opinion here as to the merit of the proposed changes—the changes sought to be made in the patent system through the presentation of such a bill. But in respect to the unfavorableness of the time and the public temper—I think there is much difference of opinion on that point. We had better educate public opinion further before attempting to obtain legislation. Mr. Walker has never met anybody who was opposed to patents. I have met a very considerable number of persons who have a distinct opinion unfavorable to the patent laws—unfavorable to any patent laws. I have heard a number of intelligent persons say that we would be better off if the entire system were swept away; that if the improvement of machinery and methods and processes were left entirely to the competition of manufacturers, there would be sufficient incentive to develop and improve the arts.

Mr. Curtis—Haven't they got to strike out a part of the Constitution of the United States in order to reach that?

Mr. Phelps—Isn't the provision that Congress *may?*

Mr. Curtis—Yes, but it always has been considered an imperative duty.

Mr. Phelps—Well, however unreasonable such opinions may be, there are a considerable number of people who hold them.

Mr. Curtis—You may perhaps find a great many people that do not know there is such a provision in the Constitution.

Mr. Phelps—Precisely. Inasmuch as the editorial in the Electrical Engineer has been referred to, I may say perhaps repeat here some of the points therein presented. As to this point which is brought out by Mr. Curtis that many people do not know anything about the constitutional provision for a patent system, there is an immense amount of ignorant prejudice in the public mind. The subject is not well understood; and in view of that and of the constant recurrence of these unsuccessful attempts, which Mr. Walker has told us of, to interfere with the patent law, the indications are that if an opportunity be offered for renewing attacks all along the line, it would probably be availed of to a very considerable extent; and it is not at all unlikely that a very large number of members of Congress would be very greatly influenced by public opinion hostile to patents. If we could feel quite sure that the commission would be headed by Mr. Curtis, and composed of men like him and Mr. Steuart, we should have no hesitation as to *their* part of the work. The hesitation comes in as to what would be done with it after they had formulated it, and it seems to me we have little to expect from any early Congress. The bills to reform other features of the national polity have not always fared very well at the hands of Congress. I do not know why we should feel certain of having wise and discriminating action taken by that body upon a measure to reform the patent law.

Mr. Walker—The last tariff law came from a commission.

Mr. Fowler rose to speak—

The President—I would like to ask Mr. Fowler to preface his remarks with a few of the statistics he has recently compiled with regard to patents covering electrical inventions.

Mr. Fowler—I have understood from good authority that three-fourths of the manufacturing interests of this country are based on patents, and I think that in the electric art we can safely say it is nine-tenths, because nearly every electrical appliance is patented in one way or another. Up to date there have been 375,000 patents, and nearly 12,000 of them are electrical patents, say one-thirtieth of the entire number. Most of these electrical patents have been granted within the last 10 or 12 years. About 25,000 now issue yearly—and about 30,000 applications are filed. In the electric art there are about 4,000 electrical applications a year, or about 75 per week. I think this will show the importance of this subject to electrical men. It would be safe to say that almost 10,000 of the 12,000 electrical patents that have been granted to date have been granted within the last 10 or 12 years, averaging nearly 1,000 electrical patents for each year during the last 10 years. Before taking my seat I should like to say something upon the paper that has been read this evening. I stand here as a representative of—I do not know but it may be called the patent office mill—I have been through it and I have been in the electrical part of it. Mr. Steuart, I think, has dropped into an error in respect to the Patent Office paying all its expenses since its organization. In a paper which I had the pleasure of reading before you a year or so ago I mentioned that the assistant commissioner had looked up this point. In years gone by the printing that was done for the Patent Office was done by an appropriation of Congress and not out of the Patent Office fund. Recently the expenses of all printing have been deducted from the Patent Office fund. This assistant commissioner, 10 years ago, I think,

ascertained that including the cost of printing, the expenses of the Patent Office would have been about equal to the amount of the receipts. From the speaker's remarks this evening one would be led to believe that there was no such thing as an examination in the Patent Office for admission. I can tell you all that there are some examinations held in the Patent Office, and pretty hard ones too. I have seen graduates from the Yale scientific school, from the Princeton scientific school, and from the various scientific schools of this country, and from West Point, come down to the Patent Office. They were going to get in, but I have seen a great many of them—the most of them—go back. The examinations they hold there are quite technical. I have been through them, and I have had to study very hard to get through them, and I started with a good scientific education. It has also been the practice of the Patent Office in years past to make the examination include questions on patent law; formerly nearly all the questions were on patent law. Latterly they have been directed more to scientific subjects. For promotion in the Patent Office, the questions are largely those of practice and patent law. Among the examiners will be found a great many who are quite well versed in the law. There are in Washington three night schools turning out lawyers by the hundreds, and a great many examiners in the Patent Office are students in those law schools. The speaker takes exception to one examiner ruling differently from another. You will find the same thing in the courts. The questions that arise in the Patent Office among examiners on applications are not so much questions of law as they are questions of fact, and where you find questions of fact you will find men differ. It is an old saying, "So many men so many opinions." It is true in the Patent Office, and I do not see how it will be possible to harmonize the rulings of such examiners. Of course an *ex parte* proceeding does not bind every one. It is well known that an application for a patent is an *ex parte* proceeding. It is not contested at all, and it is no wonder that they are sometimes overturned in the courts, and I think there is a presumption in favor of a patent always. I think the courts recognize a *prima facie* right when there is a patent. This question of Patent Office reform is a question that has been studied within the Patent Office. The examiners have made a great study of it. Some years ago they took steps in this direction. It was in the particular direction of an increase of salaries, and of course that was considered a salary grab, and it was not very successful. The speaker has enumerated a large number of objections to the patent laws that are highly visionary. It strikes me that the system as a system with some few exceptions is a very good one. I heartily concur with him in the wisdom of establishing a patent court, and I think he will find that the Patent Office itself desires such measure. Almost every one believes that the judicial functions of the commissioner should be taken away and his office made purely executive. It strikes me as far as the Patent Office is concerned there are only two things the matter with it. One thing is the inadequate pay of examiners. If the pay of an examiner is increased, say doubled,—I mean all through the assistants,—the tendency will be that men will stay there, and a man that has been a long time in the examining corps can perform three to four times the amount of work than one who has been there for a short period can do. It strikes me that this is the one thing needed in the Patent Office, increased pay, and there might be an increase of force. As to the appointment of a commission it seems to me that the patent law could be revised by direct application to Congress. There is a standing committee of the House, and there is a standing committee of the Senate, and the chairman of the Senate Committee is ex-secretary Teller, of the Interior Department, who knows all the Patent Office workings and who has in times gone by had a great many cases of appeal to him from the Patent Office, before his jurisdiction was overruled by the Supreme Court of the District of Columbia; and I think that if the National Electric Light Association, were to appoint a committee to confer with the patent committee of the Senate or of the House, that reforms could be effected more readily than by appointing a commission. It is a more direct application of power than the other way, and I think we all believe in applying power just as directly as possible.

Mr. Phelps—Mr. Chairman, on one point I wish to add to what I have said. I have had some conferences with other persons in taking a position on this matter. I have not trusted merely in my own views and apprehensions. I have been told by an attorney of prominence and large experience in patents as well as other branches of the law, that he went to Washington some two or three years ago with the express purpose of initiating a measure to remove the very objectionable limitation of United States patents by foreign patents; and that having consulted with various persons in and out of Congress with respect to the matter he concluded that he had better say nothing whatsoever about it, better drop it. In his judgment there was danger then of inviting attacks on the patent system, through amendments and otherwise, even in respect to such a specific measure as that alone. I confess that incident has influenced my mind very considerably in forming an opinion upon the expediency of the measure before us.

Mr. T. D. Lockwood—I stand before you this evening the representative of perhaps the best contested patent in the world—the Bell telephone patent of 1876, and yet I like the patent law of the United States. I am not in the best condition to talk, because I have not heard the previous discussion and I have not heard the paper, and I have just come from a dinner of about 14 courses. Nevertheless, as the last seven years of my life have been spent with greater or less success in studying patents, I thought it right that I should say a word. With all the evils of the patent law of the United States, it is yet the best patent law in the world, and my experience is that the patent law is not one-tenth as immoral as patentees themselves are. One man gets a patent for a steam engine. It is the first time perhaps that a steam engine has ever been invented. Another man gets a patent for a crank (*a*), and fastened down to the end of the main shaft (*b*), and attached to the reciprocating connecting rod (*c*), with a brass bushing in it (*d*); and the second man cannot comprehend for the life of him why he has not got the right to use the steam engine, and he goes ahead and uses the steam engine, and a suit in equity is brought against him, and when a preliminary injunction is obtained he poses before the world as a martyr to inefficient patent laws; and then he goes to work and makes a slight variation in his patent, and gets perhaps a new element in the same old claim, and goes on infringing, and he is prosecuted again, and is enjoined again, and he poses before the world as a double martyr, and then gets a few more of his kind together, and they form an association for the protection of patentees. Then a few gentlemen who really are patentees think it would be a good thing to be protected also, and for the sake of their own virtuous patents they combine themselves with the immoral patentees, and get a pretty good lawyer, sometimes a first-class lawyer, to frame a bill, and it usually is to protect the innocent purchaser, and the innocent purchaser nine-tenths of the time knows very well that he is purchasing a patented article, because it has got the patent stamp very likely so emblazoned on one side of it that he cannot put it straight on the wall to save his life, but it has got to be hung bias. For these reasons, and many more reasons, I believe that we better let well enough alone. I have noticed in the last seven years that whenever Congress goes to interfere with the patent law, they interfere with it the wrong way. Two-thirds of Congress have got the notion which prevails in Wisconsin and Minnesota and the northern side of Dakota and Idaho, and a few more places like that, that the patent system is nothing more nor less than a system of wholesale swindling, and I was very glad to see by the Supreme Court decision last May, on the driven well patent, that the Supreme Court of the United States was not going to be influenced by popular notions or popular sentiments. I was glad to see that the Supreme Court could sustain a righteous reissue. Even now the present Congress, which has not been in existence much more than a week, has begun to get in its work. I noticed last Friday morning that the regular innocent purchaser bill had already started on its march. I am very much of the opinion of Mr. Phelps and of Mr. Kintner that at the present time it would be unwise to try to get any patent legislation. I am sure that if we stir the matter up we shall stir it up more than we want to. If we get a commission, our worthy President, with the best intentions in the world, will nominate two commissioners from Michigan, and two commissioners from Indiana, and one commissioner from Ohio, and I am very sure that that commission will consider it its duty to point out what one gentleman very forcibly did this evening, and say that the Constitution does not provide for a patent law; it only provides that there may be a patent law, and condemn the ignoring of that article of the Constitution which intimates that if there is a patent law it shall be to promote the arts and sciences. I am very glad that in these days of corruption, of judicial corruption, we have in the courts of equity, upright judges, judges that are well versed in the law, in patent law, and who usually keep that provision of the Constitution before their eyes, and keep the idea of that article of the Constitution before their eyes, that a patent law is not to oppress people who use useful instruments, is not to provide that certain advantages and certain monopolies shall be given to certain people, but that in consideration of some useful thing furnished by an American inventor, that man shall be protected in the manufacture of his invention for a certain limited period. Now, with respect to the Patent Office, we cannot deny that there is a good deal of inequality of practice, notwithstanding the eloquent defense made by the gentleman on my left. Those of us who have practiced before the Patent Office have sometimes had the ill-fortune to have a case before three successive commissioners, either by an interference or by a double interference, or by some patentee who comes in at the very last minute, or by the inability of some examiner to distinguish between matters of form—matters of law—and the real subject of the case in the class of electricity. Since I have begun to send applications to the Patent Office we have had the immortal Wilbur as first examiner in the electric class. We have had H. C. Townsend. We have had Dr. F. L. Freeman. We have had Mr. C. J. Kintner, and now we have Mr. Brown. Every one of these examiners to my certain knowledge has made different rulings upon the same point with the best intentions in the world. Mr. Wilbur used to make rulings I think that would help his own pocket out. Mr. Townsend was about as fair a man as I ever knew. Dr.

Freeman was first-class, but a little indisposed to work. Mr. Kintner always recognized the difficulty of formulating a proper electrical claim, and allowed considerable latitude. Mr. Brown, filled from the sole of his foot to the crown of his head with law, but knowing very little about electricity, is disposed to stickle for matters of form. It may be that the gentleman is here. If so, I assure him that I do not mean any disrespect; but he came to the class of electricity from the class of hydraulics. Now how can a gentleman, no matter how good a lawyer he is, become an accomplished electrician in the twinkling of an eye, simply by being transferred from one part of the Patent Office to another? I do not know. It may be that he passed the competitive examination spoken of. If so, I have nothing more to say. If he passed it, all is well. I hope when Mr. Brown has fully learned electricity, and learned it well, that he will stay there, and that by that time we shall have some provision, either with law or without law, whereby examiners are well paid if they are good ones. I have nothing to say against Mr. Brown's rulings. It would be a benefit if we could get some uniformity, and if we could get Congress to allow the Patent Office to spend the money which the Patent Office earns. Once more I wish to express my opinion that it is not wise, in the year before the general election, to stir up any general legislation on patents, and I do not think that a commission is the best way to do it. I think we shall have to go straight to Congress and get some kind of a law which is formulated after mature deliberation and consideration by all those having an interest. By a congress of patentees, if you will, with the best legal talent we can get.

Mr. Frankland Jannus—I do not think that after all that has been said there is much more to add relating to the patent law itself. I agree with Mr. Lockwood that it is a very excellent thing as it stands, and as the matter appears to me there are only a few details that need immediate attention, and those I think are urgent. I refer first to the entire divorce that I think there should be between American and European applications. We do not pay much attention to European law. European countries do not pay any attention at all to ours. And why we should be hampered by them I never could at all understand. Now there is no better illustration of the danger of meddling with the patent law than what comes in connection with foreign patents. Take the matter of the international convention. That thing has been fixed and yet it is absolutely inoperative for the reason that our representative did not know the difference between the filing of an application and the granting of a patent. Now as I understand it to-day if you can get a case into the office and if you can get it through inside of six months, then you can take advantage of the balance of the seven months, otherwise it is of no importance to anybody. That is just a trifling example of the intelligence and information displayed by our legislators on patent matters. No doubt the person who conducted the United States negotiations was perfectly sincere in his intentions. But the result is not good. Then after that matter has been disposed of we want something in the matter of reissues. Mr. Lockwood has referred to a righteous reissue. It is hard to say what that is. It seems to me a reissue is righteous when the Supreme Court of the United States says so and not until then. I think that a great many of the difficulties and troubles from which we actually suffer exist in the Patent Office. I have thought so for a long time and I think so still. I think that reform is needed and we do not want to go to Congress for that because we will get nothing. If Congress will do anything about the rules of practice I would like to have them, but I doubt very much that they will. I have never yet known of an instance where an examiner was ousted for incompetence, and there is not a man here to night who has practiced before the Patent Office who does not know that there are many examiners who are incompetent. Many are competent, I admit that; but incompetent ones exist. There are men in prominent positions in the Patent Office to-day who got in before the examinations began. They could not pass an examination to get in now, if they were once out, and the only course for a man when he knows his application is being considered by such a person, is to wait until the chief comes back and get it into some other hands, because if a man has got your case pigeon-holed you are stuck right there. You cannot do a thing. The only thing is to wait until you can get a change of venue in some way or other.

Now we all appreciate the supreme importance of a record of previous cases in considering the validity of a particular patent. We all know that we have to go to the original files; it is there we get the original information. We want to look at the references, etc. Now it is a fact that when you go back of a few years you cannot find a complete file in the records of the Patent Office. I do not mean to say there are none, but I mean that back of the few years the files are very incomplete. They contain the specification and letters and probably a printed copy of the specification, but no drawing. Then as the record room is about a mile and a half away from the file room, there is only one single mode in which you can get the whole case together, and that is, to buy copies of everything you want in order to be able to look at them altogether for about 10 minutes. I once called Commissioner Montgomery's attention to the matter. He said, "Why certainly,—Mr. Duryea won't you see to it that these copies are put in these files?" I felt that I had accomplished something. I went up there again in a few weeks and asked somebody if he had heard of this being done. It had not been heard of. I went to see the commissioner again. He scratched his head and seemed to try to recollect, "Oh, yes, Oh, yes," he said, "Mr. Jannus, if you will put that matter in writing I shall be ever so much obliged to you." I proceeded to do so. In the course of a few days I received a very courteous reply which said in substance, "that the matter referred to in my communication of such and such a date had been referred to a committee consisting of the chief draughtsman, the chief clerk and one of the principal examiners, and that they had decided that, whilst it was very desirable that this thing should be done, still that there was no force at the disposal of the commissioner with which to accomplish the same; that it was eminently desirable, but that it could not be done, and he kindly concluded with the suggestion that I call the attention of his successor to the same thing. I do not know whether his successor has got around to that or whether he ever will, or whether I ever shall. I think that the surplus of which we have all heard so much ought to be applied to attending to that matter.

I remember once being particularly struck by the effect of the statement on my part that the Patent Office was responsible for nothing and responsible to nobody. I got to thinking about it afterwards myself and the more I think of it the more I appreciate it—it is a fact, and it is that irresponsibility that gives rise to a good many very peculiar actions. It does not make any difference how much an examiner annoys you, or impedes the progress of your case, there is absolutely no responsibility on his part. There is nothing he can do, judging from the history of the office that will secure his dismissal or reprimand or anything whatsoever! The only thing you can do is to appeal. That it seems to me ought to be remedied in some way. A man goes to the Patent Office with a case; he is instructed in the art and he knows it is new. His attorney kows it too, of course, as his client has told him. Well, the case is taken up by some junior, some new man, probably in the office only a week or two,—which very often happens—especially in the case of electricity. Now the reference is not well considered and the burden is thrown entirely upon the attorney and his client to demonstrate to the office, to explain to the examiner, what the reference does show, and then call attention by contrast, to what the application shows. That is a thing of daily occurrence. I think that after a man has shown evident incompetence that he ought to be incontinently dismissed. I think there are plenty of good men to be had. Now it is a regular thing for a fellow to examine a case and fling a lot of drawings at you and let you fight it out yourself, afterwards. I do not think that that is the intention of the rules. I do not think that is what ought to be done. I do not say it is done in every case, but it is done in too many cases, and it is these things that keep the work of the office back and hamper and annoy everybody connected with it. I have seen men deliberately order their attorneys to take claims out after their attorney had advised them that they ought not to take them out.

Then this shifting of examiners from division to division is another source of delay and trouble, as in the case of electricity, where the chief examiner comes from water works to electricity. It practically blocks the progress of a class for a long time. Then, when you come to add his lack of familiarity with the subject, his overwhelming disposition for technicalities, why, altogether, you get a very interesting combination.

Now in the division of chemistry there is a gentleman, a very nice fellow outside of the office, but then he is always ready to deny the operativeness of a process. He is not going to find out whether it is operative or not. The fact that he will in all probability be proved wrong has nothing to do with the case. You have not proved that it is operative. You have not submitted specimens, and that is the end of you until you do. I have cases there now and I know that they are operative. The man who says they are is a man of fifty years' experience; yet this official with no experience at all outside his room says it is not operative, and the case is clogged until it becomes convenient for my client to prove otherwise. Now I have heard it suggested by a friend who has been very highly spoken of here to-night, that the day of a close examination in the Patent Office was gone, that the system of examination—the system at present theoretically in existence—is obsolete. His idea is that the examiner should take up a case, point out objections—insufficiency of descriptions, and all those things just as he does now, and then cite all the references he has got tending to show the lack of invention; that after receiving those references it should be the duty of the applicant to amend his case as he might see fit; take out his claim, limit it, expand it, do anything he chooses, and then send the case to issue. That struck me at first as a most iniquitous proposition; but I think it will bear consideration, because the courts will be the ultimate tribunals before which that case will be settled. For when the office has cited its references then that branch of the case should be closed and sent forward. The applicant takes the risk in it. The favorable dictum of the Patent Office does not hold before the court. I think that there is where the responsi-

bility falls in view of the fact that the courts constitute the only ultimate tribunal. It is not customary for people nowadays to put money in patents without at least looking at the file, and the moment that is done they are in possession of the data upon which the courts would have to decide and upon which they might as well decide also.

I certainly agree with Mr. Steuart that the patent law needs some revision, but I am a little doubtful in my mind whether this is the best time to do it or not. Some think it is; some think it is not. I think if we were to go for two or three inoffensive amendments we might get them. If that cannot be done, as many gentlemen seem to think, then I favor the plan of a commission, because this thing of going to Congress always gives rise to the suspicion that the parties who go have an axe to grind. The question is, how can these lawyers afford to come here and ask for these things? People in Congress ask these questions as well as other people. The answer naturally is, they are trying for legislation for some particular thing, and especially are politicians liable to those suspicions. They think of that first, last, and all the time, judging from what they say, and for that reason I think the plan of a commission would be the best, because the matter can then be presented to Congress in an impartial manner. Whether this present time is or is not the best I do not know, but I think if it is decided to apply for a commission that this time is as good as any other, because it will certainly take them time to consider the question, and to formulate what they want, and before they get any hearing from Congress, and I doubt very much whether the matter could be brought to the attention of Congress until after this bugaboo of the presidential election has passed.

Mr. Lockwood—I crave your indulgence for one or two remarks. Words would fail me if I should attempt to depict the interest with which I have listened to the remarks of Mr. Jannus; and while I cannot agree with every one of his propositions, I may say that I can cordially agree with some of them. For example, I can agree most cordially with his proposition that the aspect of our patent law with relation to foreign patents does need revision. But I do not think that a commission is the best means of accomplishing it.

With respect to the reissue question I do not think that the law needs any revision.

Mr. Jannus said that he never heard of any incompetent examiner being dismissed. I never did either. I do not think anybody ever did. It is the competent examiners that get out of the Patent Office. It is the incompetent ones that stay in. But I would like to add a doxology to his remarks there. I think it is equally necessary that there should be some kind of an examining committee for attorneys. I never heard of an incompetent attorney being dismissed permanently. I have known a good many to be dismissed from one client but simply to catch on to another one. And it is a pretty safe rule I think to fight pretty shy of those gentlemen who flood you with circulars after you have got a patent. It strikes me that there is something in the matter of Patent Office tribunals that needs rectifying. I do not know how the law is going to get around it, because the patentee seems to think his rights are infringed if he is not allowed to handle the tribunals of the Patent Office as he sees fit. If we get an adverse decision we feel very bad if we cannot appeal to the board of examiners in chief, and so on. So I do not know with my present information where to take hold of this subject of a tribunal. I think that needs a little more attention perhaps than has been given to it. Now we should all of us who practice before the Patent Office or are interested in patents, be prepared to bear patiently with the custom of examiners who deal with applications in an impartial and square manner. If they allow a patent which afterwards turns out to have other references and which is not new, I think we should remember that it is utterly impossible in the present state of knowledge and in the large expanse of publications and of prior patents which they have to wade through to cover the grounds every time. We have got to take our chances in the matter, and those of us who have taken out patents for inventions know we have got to get out patents for the inventor by hook or crook. As a rule the inventor does not care whether the claim is valid or can be sustained or not. If he has got a patent he can easily sell it. My experience is, no matter how foolish a patent is, how unduly broad a patent is, how ridiculous a patent is, all you have got to do is to find somebody with more money than brains and you can sell that patent, and you can organize a company with seven millions of dollars of capital on it, just as easily as you can with the best invention ever made. So I think we must not be too hard on the examiners. There are a good many ways we can help them. As a rule an examiner is open to conviction; the average examiner is, I am sure. About five years ago I filed an application for a patent before a certain examiner, which I think I could have made to cover broadly the conversion of electricity of high potential to electricity of low potential, for the purpose of getting incandescent lamps from the high potential circuits by means of induction coils, and the examiner (he was ignorant, but he was honest) said,—It cannot be done. He said, there is no such thing ever heard of as working an induction coil backward. Well, it was within the extent of my electrical knowledge that it could be done—that it had been done, for I had done it myself—and moreover I knew that the conservation of energy would work almost any way, backwards or forwards. But I had a gentleman for a client who was afraid to give me rope, and the application was put upon a shelf. In such cases as that the examiner is not to blame for sticking to his views, but the client is to blame for not sticking to *his* views. For my part rather than take a claim out which I knew I was entitled to I would let it stay in the Patent Office until the crack of doom.

Mr. Fowler—I think if the National Electric Light Association were to present some bill in Congress which would increase the pay of examiners say 50 or 100 per cent., it would go further toward removing the evils of the Patent Office than anything else combined. In one year 23 examiners resigned—about one-sixth of the whole corps. The Patent Office now is filled with new men. Until a man has examined for one year he is absolutely worthless in the Patent Office. I have been troubled a great deal myself since I have been out of the Patent Office with these questions of form, and I know exactly what it means. If gentlemen here had any conception of the work that is thrown upon examiners they would know what it means. It is a great deal easier to raise a question of form than it is to go down and examine the merits of the case. These questions of form are raised by men who are so banked-up with work that it is "anything to get rid of a case." If the salaries of these men are raised and these men are kept there who can perform three or four times the work that new or inexperienced men can perform, reform will follow. I was talking with an examiner, a friend of mine, whom I met in New York a few days ago, and he said "This is the way to work (and I thought it was a very poor one); it is anything to shelve a case." He has little rollers, stamps, that he rolls across the paper—the division, record, process and everything, *ex parte* something—he rolls them over the sheets and hands them over to the clerk, and she writes a letter. That case is got rid of. I was very much struck with this question of form when I was in the Patent Office. There was a case which had been on the merits twice to the board and once to the commissioner, and it was a case we were very much harassed about. It was a question whether the thing was patented, and one of the gentlemen in charge asked me to take hold of the case and make an examination upon the merits. I spent some little time at it and I found two English patents for exactly the same thing, and yet the case had been appealed to the board twice and to the commissioner once upon the question whether the thing was patented. That just illustrates the point exactly. They will raise these questions of form to get rid of the case rather than examine the merits, because it looks too long. They want to be up to date with the work as near as possible.

Now this question of limiting American patents by foreign patents does not strike me as being a very serious thing. Trouble is easily avoided. It is a general impression that all foreign patents limit an American patent, and yet it is only so when a foreign patent is previously issued. It is easy enough to file your foreign application on the same day that the American patent issues.

I am a believer in compulsory licenses as they have them in England. I do not think one man should be able to get a broad claim. I know my friend on the right will not agree with me in this. I do not think one man should be able to get a broad claim allowed and prevent improvers from using improvements. That is what the laws of this country gives them. In England a Board of Commissioners ascertain how much a license is worth and they make a man with a foundation patent give a license to another party so that an improver can use his invention. There are many companies in this country who have valuable improvements locked up in their safes. In that way they impede progress. I have in mind one company who say they do not want to change the machinery, although there are a great many inventions in their line that are better than the devices they use; and they buy up such patents and put them in their safe.

Mr. Jannus—I did not have the slightest intention of reflecting upon the entire staff of the Patent Office, because I know there are plenty of good examiners; I merely referred to those that were not, and to the fact that despite the examination for admission the force is not as good as it might be. I fully agree with what has been said about raising salaries, and I fully endorse the proposition that that would in a large measure modify present troubles in that respect. They want more men, and they want to have them more competent. Both things are necessary.

Now the question of reissues is a very serious one. I passed it over, as I did other matters, believing it to be almost too late to go into it, but there is one thing on that question I would like to voice—that is, the trouble in the way of an inventor in securing what has been apparently lost by a defective patent is principally owing to the fact that it is a conclusive presumption that everything that is shown in a patent and not claimed is abandoned. If there is any way of overcoming that, then we will have actually what reissues were supposed to cover. I do not believe that the reissue law was ever meant to cover a case where a man went in and expanded an application after he had found the desirabili-

ty of doing so. I do not think it was ever intended, and the Supreme Court evidently does not; but I think that if reissue is confined to the subject-matter found in the claims actually patented, giving it perhaps a better expression or some greater scope, a scope evidently due to it, and that then the applicant can remove from the defective patent the subject-matter of a different character which was not covered in those claims, then relief can be found. As the matter stands it is a fact, and I think it will not be denied, that it is almost impossible to do anything with an invention after it has been badly patented. But as I said before you never know what is a good reissue until the Supreme Court has passed upon it. That question I feel to be too deep and too serious for our discussion to-night and, therefore, will leave it.

Mr. J. A. Miller—I should like to say a few words. I have practiced before the Patent Office since 1854, and I do not know that any attorney practising before the office has been so unfortunate, particularly in one room, in his intercourse with examiners as I have been. I speak of the textile room. Now I have felt all these difficulties which have been spoken of by the various gentlemen here, and have suffered considerably. At times I was almost disgusted with the actions of some of the examiners, but about four or five years ago I had three very important cases which were rejected in Germany, and I went to Germany to appeal. Since that I have been satisfied with our Patent Office and with the practice in our office.

Mr. Jannus—An ex-commissioner had the same experience recently.

Mr. Miller—As to raising the salaries of examiners as a whole, I never did believe in that. I believe more in the European system of putting a high premium, high up. I believe in paying the chief examiners a very high salary, but I think the young men can get along with a lower salary, and I think the present salary is sufficient for them until they have striven and gained a higher position.

There is another remark I wish to make on this question of a court.

We have all suffered very much by appealing from the board of examiners in chief to the commissioner and not getting quite to the commissioner In fact we do not know where we are when we get there. The examiners-in-chief are very honest men but they get into ruts. If you have an argument before them you know just what you are to say and it depends on who is to write the opinion, and if you happen for instance, to take the question of employer and employé and get started wrong on that, you cannot win to save your life.

Mr. Davidson—I submit that there is no system for the administration of affairs among men that will not be open to numerous objections from—may I say—theoretical perfectionists. Now the patent system is not perfect; we will admit that. There are perhaps many ways in which it may be improved. There has been quite an extended discussion as to the imperfections of examiners. We attorneys are perhaps quite as much as the examiners, tainted with original sin. We are not perfect. Our judicial system is not perfect. The question we must come back to is this—is not our patent system as we have it do-day the best that we can get with some trifling corrections, and would it be wise for us to open the door to a general revision of the entire system and invite changes which will require interpretation, which will require decisions to mark down all the lines of how they are to be interpreted and overthrow doctrines in regard to patents based upon some 3,000 or more judicial decisions? I think not. As soon as a revision of the laws is invited by a commission such as has been suggested, every man with a hobby in regard to the patent law will appear or combine with others, and appear before such a commission and seek to grind his own axe. We will have before such a commission all the gentlemen who are in favor of protecting innocent purchasers. It seems to me I may be permitted to bring the discussion to what I understand to be the real point of it, that is, the propriety of making an application to Congress for the revision of the laws. Everybody assumes there are some imperfections. I should think we ought to treat them like any other business enterprise. No business man goes to another and says, I have got a claim against you; I don't know just what it is, but if you will help me to find out, I think we can get at it. That is no way to get at it. We ought to decide what we concede to be the points to be secured for the improvement of the patent system and then when we know just what we want, to go and ask for it and let the manufacturing interests, and let the inventors bring in their influence to bear upon the politicians. I believe in practical statesmanship. I do not believe in ideal statesmanship. Let us select those things which are obtainable and make a direct application for them.

Mr. Wheeler—I think that some time ago Mr. Phelps introduced a resolution, and in view of what has been said I would like to second it.

The President—Will Mr. Steuart address us again. He may wish to reply to the remarks that have been made.

Mr. Steuart—Gentlemen, I have very little to say in this matter. I came here for the purpose of hearing what you had to say, and I prepared my paper for the purpose of making a text for this discussion, and I am very glad you have so freely and so fully expressed your opinions. There seems to be a somewhat equal division of opinion with reference to the proper course of procedure. I cannot help adhering to my original view with reference to the best course. It seems to me that we can introduce into Congress a bill providing for certain specific changes in the law which is the result of the work of a competent commission who have investigated the subject carefully and who bring in a report which comes from neutral men unbiased by any personal interest, and unbiased by any special class interest in such a position that it cannot be classed as class legislation, that we will stand before Congress with a better chance of accomplishing the results that we have in view than we could possibly have were we to go now before Congress or any other time with specific legislation. While I think much good could be obtained by a bill that would provide for any one of these suggested changes which have been discussed, if a bill were introduced providing for an increase of salaries to the examiners it would do great good. If a bill were introduced for a tribunal it would do great good if it were passed, but when we are going about the thing at all it seems to me that we want to put ourselves on the floor of Congress in the strongest position that we can take there, and the way to do that, as well as I can understand it, is to go there with a report of a neutral commission, and we will have a better chance than we could possibly have by a bill prepared by any class of business, whether lawyers or manufacturers. I will say, in conclusion, that I think the resolution that has been introduced is unnecessary, because I do not know that it will have any special object or any special effect—any special purpose. The meeting of to-night was called for the purpose of having the discussion which we have here engaged in, and of seeing what was the best that could be done. It is preliminary in its general character. There will be a convention of lawyers and manufacturers held in Washington the first week of January, which will be under the auspices of the patent bar association of the city of Washington, and I will be very glad, and I am sure they will be very glad if all of you who are interested in the subject will attend that convention for the purpose of hearing the subject considered as elaborately as it will be there discussed. The meeting will last several days, and there will be representatives from several cities. I think that in view of that meeting, and of the very much more full and elaborate discussion that will there take place, any action on this resolution would be premature at this time.

The President—I think it lies within my duty to say that the resolution says "it is the sense of this society." This is a special meeting, and I do not think we could pledge the Institute one way or the other, and I would like to point out in addition to that, that we have on the secretary's desk a bulk of correspondence from some of the leading inventors and patentees and patent experts of the country, embracing various opinions, and certainly before we express a definite opinion one way or the other of the Institute, it would be well to know what lies in that correspondence which should guide our action in addition to what we have heard this evening. I merely throw that out by way of suggestion.

Mr. Phelps—I am not disposed to press the passage of the resolution.

On motion duly carried the resolution was laid on the table. The meeting was then adjourned.

The next meeting of the Institute, to be held on Tuesday, January 10, at the house of the American Institute of Civil Engineers, will be of a very interesting nature, as a paper is to be presented by Mr. Willard E. Case, of Auburn, N. Y., on the production of electrical energy directly from coal. Mr. Case, who has made extensive investigations in thermo-electricity and has succeeded in utilizing simple coal as one of the elements of a chemical battery, will give the results of his experiments and discoveries. Some of the recent thermo-electric batteries will be exhibited, illustrating practically the new departures in this unfamiliar field of research and application.

THE FLORIDA ELECTRICAL SOCIETY.

A considerable number of gentlemen connected with electrical interests in Florida met at Jacksonville, Nov. 23d, for the purpose of forming a society for the advancement of electrical knowledge among the members, the organization to include the establishment of a library, a reading-room and laboratory, also the holding meetings at which the reading of scientific papers pertaining to the subject, and their discussion, will be leading features.

The organization was perfected under the name of the Florida Electrical Society, with the following officers: B. F. Dillon, president; L. E. Spencer, 1st vice-president; W. R. Davis, 2d vice-president; G. W. Davis, 3d vice-president; J. S. Arnold, 4th vice-president; Edward B. King, secretary; D. J. Crowley, treasurer; R. B. Rood, librarian.

THE TELEPHONE IN NOVA SCOTIA AND NEW BRUNSWICK.

Through arrangements made with the Bell Telephone Co. of Canada, by enterprising citizens of Nova Scotia and New Brunswick, the telephone business of those provinces will be conducted under a single and independent management.

New life has recently been infused into the business by Mr. A. A. Knudson, of New York, who has spent some time in the provinces re-organizing the service and introducing new apparatus. The introduction of the "Law" switch-boards is said to have greatly improved exchange service at Halifax.

THE INTERNATIONAL EXHIBITION OF 1888 AT BRUSSELS.

Messrs. Armstrong, Knauer & Co., 822 Broadway, New York, authorized agents, send us a schedule showing the classification of electrical exhibits at the Brussels International Exhibition next year. The "forty-seventh competition" of the exhibition comprises "applications of electricity," and is classified as follows:

GENERAL CLASSIFICATION.

Subdivision 47*a*.—Study and teaching of electric science, measuring instruments, scientific application of electricity, lightning rods and conductors.

" 47*b*.—Dynamo-electric motors and machines. Transfer of the moving power at a distance. Distribution of the electric energy, transformators.

" 47*c*.—Telegraphy, telephony, wires and cables.

" 47*d*.—Arc and incandescent lamps.

" 47*e*.—Electric batteries, accumulators, sundry industrial applications; electro chemistry, electro metallurgy, galvanoplasty, railroad signals.

Under the head of "Proposed Questions—Desiderated" the circular sets forth in considerable detail the points of competitive examinations to be made for awards in each class.

Applications for space must be filed before January 15th.

Messrs. Armstrong & Knauer will furnish all information desired, upon application, personally or by mail at their offices, 822–824 Broadway.

ELECTRIC LIGHT AND POWER.

The Westinghouse Electric Company's List of Central Stations Using their Alternate Current System.

	Location.	Operating Company.	No. of 16 c. p. lamps.
1.	Allegheny City, Pa	Allegheny County Light Co	5,000
2.	Altoona, Pa	Mountain City Electric Light Co	650
3.	Austin, Texas	Austin Water, Light & Power Co	3,900
4.	Baltimore, Md	Brush Electric Light Co	5,000
5.	Bath, Maine	Bath Electric Light & Power Co	650
6.	Beaver Dam, Wis	Beaver Dam Electric Light Co	1,300
7.	Bennington, Vt	Brush Electric Light & Power Co	650
8.	Buffalo, N. Y	Buffalo Electric Light & Power Co	1,950
9.	Buffalo, Wyo. Ter	Buffalo Electric Co	650
10.	Carbondale, Pa	The Flectric Light, Heat & Power Co	1,300
11.	Cedar Rapids, Ia	Cedar Rapids Electric Light & Power Co.	1,950
12.	Charleston, W. Va	Kanawha Electric Light Co	650
13.	Chattanooga, Tenn	Brush Electric Light Co	650
14.	Cheboygan, Mich	Cheboygan Electric Light Co	650
15.	Colorado Springs, Col	El Paso Electric Co	1,300
16.	Columbus, Ohio	Columbus Gas Light & Coke Co	2,600
17.	Conshohocken, Pa	Conshohocken Electric Light & Power Co.	650
18.	Cornwall, Ont	Stormont Electric Light & Power Co	650
19.	Dallas, Texas	Dallas Electric Co	1,800
20.	Denver, Col	Denver Light, Heat & Power Co	6,500
21.	Duluth, Minn	Duluth Electric Light & Power Co	1,300
22.	Easton, Md	Easton Electric Light & Power Co	650
23.	Flint, Mich	People's Electric Light & Power Co	650
24.	Fort Edward, N. Y	Fort Edward Electric Co	650
25.	Galveston, Texas	Brush Electric Light & Power Co	1,300
26.	Greensburg, Pa	The People's Electric Light Co	600
27.	Hartford, Conn	Hartford Light & Power Co	2,600
28.	Hillsdale, Mich	Hillsdale Electric Light Co	650
29.	Hoboken, N. J	Hudson Electric Light Co	1,300
30.	Hot Springs, Ark	Hot Springs Electric Co	650
31.	Junction City, Kan	Junction City Electric Light Co	650
32.	Lincoln, Neb	Lincoln Electric Light Co	1,950
33.	Littleton, N. H	Littleton Water & Electric Light Co.	650
34.	Minneapolis, Minn	Minneapolis Electric Light Co	6,500
35.	Morristown, N. J	Morristown Elec. Light, Heat & Power Co.	650
36.	Nashville, Tenn	Nashville Light & Power Co	650
37.	New London, Conn	New London Electric Light Co	1,300
38.	New Orleans, La	S. W. Brush Electric Light & Power Co	5,200
39.	Newton, Kan	Newton Electric Light Co	650
40.	Oneonta, N. Y	Oneonta Electric Light Co	650
41.	Ouray, Col	Ouray Electric Light Co	650
42.	Parkersburg, W. Va	Parkersburg Electric Light & Power Co	1,950
43.	Peekskill, N. Y	Peekskill Electric Light & Power Co	1,300
44.	Philadelphia, Pa	Keystone Light & Power Co	1,950
45.	Pittsfield, Mass	Pittsfield Illuminating Co	1,950
46.	Pittsburgh (S. S.), Pa	Allegheny County Light Co	3,000
47.	Pittsburgh (E. E.), Pa	East End Electric Light Co	5,200
48	Pittsburgh (Virgin A.), Pa	Allegheny County Light Co	10,200
49.	Plainfield, N. J	The Plainfield Electric Light Co	2,600
50.	Port Huron, Mich	Excelsior Electric Co	650
51.	Portland, Me	Consolidated Electric Light Co	650
52.	Richmond, Va	Old Dominion Electric Light & Power Co.	650
53.	Salina, Kans	Salina Gas & Electric Light Co	650
54.	San Antonio, Texas	Electric Light & Power Co	650
55.	Savannah, Ga	Brush Electric Light & Power Co	1,950
56.	Seward, Neb	Seward Electric Light & Power Co	650
57.	Schenectady, N. Y	Westinghouse Illuminating Co	2,600
58	Sheffield, Ala	Sheffield Land, Iron and Coal Co	650
59.	Springfield, Mass	United Electric Light Co	2,600
60.	Springfield, Ohio	Champion Electric Light Co	1,950
61.	Stapleton, N. Y	Richmond Light, Heat & Power Co., L'td.	2,600
62.	Steubenville, Ohio	Electric Light & Power Co	650
63.	Stillwater, Minn	Stillwater Gas and Electric Light Co	650
64.	St. Cloud, Minn	The St. Cloud Gas and Electric Light Co.	650
65.	St. Louis, Mo	St. Louis West. Elec. Light & Power Co	2,600
66.	Tampa, Fla	Tampa Electric Co	650
67.	Torrington, Conn	The Torrington Electric Light Co	1,300
68.	Trenton, N. J	People's Electric Light Co	5,200
69.	Truro, N. S	Truro Electric Light Co	650
70.	Tyrone, Pa	Home Electric Light & Steam Heating Co.	950
71.	Wheeling, W. Va	The Wheeling Electrical Co	1,300
72.	York, Pa	York Electric Co	650

Mr. D. L. Davis has made a contract to light the town of Salem, Ohio, with 55 arc lamps of 1,200 c. p. for five years.

The New Albany Electric Power, Heat and Light Co. will establish a plant at New Albany, Ind.

The Rome Gas Light Co. will build an electric light plant at Rome, Ga.

The Oval Wood Dish Co. will erect an electric light plant at Mancelona, Mich.

The Birmingham Safe and Lock Co. will erect an electric light plant in connection with their works at East Avondale, Ala.

The Westinghouse plant at Oneonta, N. Y., is nearly completed, and will soon be in operation.

Foreign.

Germany.—THE FAILURE OF THE BOILERS AT THE VIENNA OPERA.—After the failure of the large electric light installation at the Vienna Opera House about a month ago, many conflicting reports as to the cause of the failure were circulated. All doubts on this point are removed by the following explanation from Messrs. Crompton & Co., and from which it appears that the interruption was due to the failure of the boilers used at the central station:—

Six steel boilers of 140 h. p. each were made for Messrs. Crompton & Co., by the Witcowitz Iron Co. in Moravia. Messrs. Crompton specified that the material used should be the best mild steel ordinarily used for boiler making. From the very first, however, the steel actually used began to give trouble; one of the plates in the water leg cracked under cold water pressure when it was tested, before steam was got up, and two other boilers failed within 48 hours of starting work. These defects admitted of temporary repairs; meanwhile work was carried on with the other three boilers. After about 12 week's work, however, similar cracks began to show themselves in the main shell of the boilers, which were then considered dangerous, and the work was stopped by order of an imperial commission. The cracking is one of those instances which so often occur with steel boilers We may instance that of the Czar's yacht, the "Livadia," which at the time excited great interest among marine engineers. The cracks in nearly all cases appeared when the boilers were cooled down and opened up for cleaning purposes. The steel used was Bessemer, produced by the basic process. The whole of the six boilers were got out from the underground boiler house, and two large sized locomotive boilers that happened to be available were got into position, and steam got up within nine days of the order to stop the defective boilers. The opera was lighted on the tenth day. The whole of the rest of the machinery was found to be in perfect order, the accumulators not having suffered in the least. With the exception of this one failure of the boilers, there has been no hitch whatever in the running of this large installation of 6,000 lights since the commencement.

Spain.—The largest independent electric light installation in Spain will be that of the Royal Italian Opera House, which is being carried out by the Schuckert company. There will be about 1,500 glow lamps, and a dozen Krizik arcs.

The town of Albacete, which has a population of about 20,000, and which has hitherto been lighted by oil, is adopting the electric light for private and public lighting, 16 c. p. glow lamps being employed. The installation will be ready in a few weeks.

The municipality of Bilbao, which has some surplus engine-power at their water works, intends to utilize it for lighting the principal thoroughfare of the town by means of 82 arc lights. Schuckert dynamos will be used.

M. Edward P. Thompson, of New York, was appointed some months ago consulting electrician of the Compania del Tranvia de Bilbao a Santurce, which has decided to substitute electricity for animal power upon its road of ten miles, at present running cars at intervals of twenty minutes. Having thoroughly investigated the leading systems in the United States, Mr. Thompson made a full report with estimates, upon request of Mr. Arias, the general manager, recommending a well-known American electric railway company, and naming others as in his opinion, worthy of attention. Mr. Thompson has been notified that a decision upon the proposition submitted by him to the Spanish company will be made Jan. 15th.

Switzerland.—The municipality of Geneva is considering a scheme for utilizing the motive power of the Rhone. A report on the subject has just been published, together with a series of resolutions for certain credits to provide for the extension of the distribution of power, to supply electric light to the theatre, and to meet the expenses incurred in the construction of sewage collecting works. Already, by means of turbines and pumps, the municipality not only distributes water throughout its own domain, but also to 15 neighboring communities. In addition, by means of 175 motors, it supplies power in quantities varying from half a horse to 70 h. p., to 145 manufacturers or artisans in their own establishments, homes or workshops, within a circle having a radius of not less than a mile-and-a-quarter from the central station. Hitherto the method of hydraulic transmission has been adopted. But in considering whether it would be best to supply hydraulic power to the theatre for conversion into electricity there, or to supply the electricity direct from the source of the power, the council has decided to combine a system of electrical transmission with its hydraulic system, because it is found that in the case of many workshops—such as those of the clock and watch makers—situated in the upper stories of buildings, as well as in the case of the theatre, there will be a saving of power by the electrical method.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horse-power; **T.**, T-rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scaife; *Sec.*, Arthur Kennedy; *Eng.*, Sam'l Drescher; 4 mi.; g. 5-2½; 54 lb.; 4 m. c.; sta. 200 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Supt.*, J. R. Harrigan; *Eng.*, N. M. Edwards; 4.5 mi.; g., 4-8½; 33 lbs.; 5 c.; 5 m.; water-power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, H. S. Iselin; *Sec. & Tr.*, D. T. Thompson; *Supt.*, J. L. Jerolamon; 4 mi.; g. 4-8½; 47 lbs.; 15 m. c.; sta. 200 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Denver, Col.—Denver Tramway Co.—*Pr.*, Rodney Curtis; *Sec.*, Wm. G. Evans; *Supt.*, Jno. C. Curtis; 4 mi.; g. 36; 16 and 18 lb.; 10 m. c.; sta. 125 h. p.; conduit cond. SHORT-NESMITH.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g.——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE. Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.3 mi.; g. 4-8½; 30 and 45 lbs.; 6 c.; 4 m.; sta. 60 h. p.; overhead cond. FISHER.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1 c.; 1 m.; sta. —— h. p.; overhead cond. VAN DEPOELE.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Kansas City, Mo.—Kansas City Elect. Ry. Co.—*Pr.*, W. W. Kendall; *Sec. & Tr.*, Warren Watson; *Supt.* John C. Henry; 2 mi.; g. 4-8½; 70 lb.; 4 m. c.; sta. 80 h. p.; overhead cond. HENRY.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr* [illegible] Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb. [illegible] h. p., overhead cond. VAN DEPOELE.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p,; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. VAN DEPOELE.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair Ry. Co.—*Pr.*, Theo. Evans; *Sec.*, J. W. Patterson; 2 mi.; g. 5-2½; 45 lb.; 5 c.; 5 m.; sta. 175 h. p.; overhead and conduit cond. DAFT.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt.*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. VAN DEPOELE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*. Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.* and *Supt.*, E. A. Smyth; *Sec.*, A. P. Friesman; 5.75 mi.; g. 4-8½; 30 lb.; 10 m. c.; sta. 1160 h. p. (water power); overhead cond. VAN DEPOELE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Supt.* B. T. Killam; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 7 m. c.; sta. 200 h. p.; overhead cond. VAN DEPOELE.

Wichita, Kas.—Wich. Riverside & Suburban Ry. Co.—*Pr.*, J. O. Davidson; *Sec.*, N. G. Lee; 4 mi.; g. 6-8; 45 lb; 6 m. c.; sta. h. p.; overhead cond.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *Eng.*, P. C. Ponling; 1.25 mi.; g.——; ——lb.; 2 c.; 1 m. c.; sta. 15 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 3.5 mi.; g. 4-8½; 30 and 50 lb. T; 9 m. c.; sta. 1,000 h. p.; ovehead cond. BENTLEY-KNIGHT.

Constructing or Under Contract.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clarke; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½; 45 lb.; 9 c.; 4 m.; sta. —— h. p.; overhead cond. VAN DEPOELE.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—6 mi.; g. 4-8½; —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond. SPRAGUE.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Carbondale, Pa.—Carbondale & Jermyn Elect. St. Ry.—*Pr.* John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; 5 mi.; g. 4-8½; 25 and 57 lb.; overhead cond. SPRAGUE.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper. DAFT.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 8 m. c.; sta. 240 h. p.; overhead and conduit cond. VAN DEPOELE.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; 1 mi.; g. 5-2½; 35 and 56 lb.; 2 m. c.; overhead cond. DAFT.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; 6 m. c.; overhead cond. SPRAGUE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, Chas. D. Haines; *Sec.* F. H. Skeele; 1.5 mi.; g. 4-8½; 25 lb. T.; 2 m. c.; sta. 50 h. p.; overhead cond. DAFT.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.

New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*. E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.

New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.

Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.

Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.

Richmond, Va.—Richmond City Ry. Co.—*Pr.*, J. L. Schoolcraft; *Treas.*, Walter Kidd; *Supt.*, Chas. Selden; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; overhead cond. SPRAGUE.

San Jose, Cal.—San Jose Motor Co.—*Pr.*, J. W. Rea.

Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, G. Clark; *Sec.*, T. C. Snow; *Treas.*, B. E. Leonard; 5 mi.; 4-8½; overhead cond. VAN DEPOELE.

South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; 3.25 mi.; g. 4-8½; overhead cond. DAFT.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond.; VAN DEPOELE.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—7 mi.; g. 5-2; 50 lb.; 2 m. c.; overhead cond. SPRAGUE.

Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

Notes.

THE eight-wheeled accumulator electric car which has been built in Philadelphia by Wm. Wharton, Jr., is undergoing a thorough experimental trial with very satisfactory results. It is propelled by two Reckenzaun motors, and 116 cells of Electrical Accumulator Co.'s battery. A recent run reported, with one charge of the cells, was 63 miles and 211 feet in eight hours, traversing 331 curves of 33 feet radius, 662 curves of 50 feet radius, and five miles of grades of 5.8 per cent., a splendid piece of work. Mr. Wharton says that the weight of the Reckenzaun motor per horse-power developed is only about one-third that of the Sprague railway motor and one-sixth that of the Van Depoele motor. He also claims that its percentage of efficiency is much higher than that of the Sprague motor.

GREAT complaint is made in Richmond, Va., respecting the uncouth appearance of the overhead structure for carrying the conductors for the new street railway. It ought to be possible to avoid this objection.

THE *Street Railway Gazette* says that Charles Green, president [illegible] People's Railway Co., and Christian Peper, of the St. [illegible] R. Co., have been "converted" to electricity.

THE LANE & BODLEY CO., of Cincinnati, have supplied the steam plant for the new Van Depoele electric street railway, now building in Dayton, Ohio. Three 80 h. p. dynamo will be driven by clutch-pulleys from a line shaft.

THE KANSAS CITY ELECTRIC RAILWAY CO., operating under Henry's system, made an assignment, Dec. 12, to Evan A. Fursell, for the benefit of its creditors. The assets are valued at $12,000, liabilities not stated. The company has spent too much money in experimenting.

THE new Observatory Hill electric railway in Allegheny, Pa., is thoroughly well built, and as it runs through a charming suburban region, heretofore very difficult of access, it is likely to prove a highly profitable enterprise.

THE THOMSON-HOUSTON CO., of Lynn, have gone into street car motor work, and their machinery is reported as doing excellent service. The Bentley-Knight company are using them on their cars.

COL. E. H. HEWINS, of the New England Weston Co., of Boston, has been exhibiting a car fitted with a 10 h. p. Weston motor, and 120 cells of Julien accumulators. The car has made several runs over the West End company's tracks in Cambridge and Boston, with apparently satisfactory results.

THE DENVER TRAMWAY CO. is about to extend its plant, and has ordered another 100 h. p. generator.

TWO of the model electric street railways of the country are the Appleton (Wis.), and the Scranton (Pa.) lines, both constructed by the Van Depoele company. They have heavy and well-laid steel tracks, elegant cars, and well designed machinery. Both these lines are deservedly popular with the public and it is almost superfluous to add, are making money rapidly.

THE electric street railway put in at Mansfield, Ohio, by the Daft company, is doing a good business and is giving excellent satisfaction.

THE new electric railway at Columbus, Ohio, is to be constructed on the Short system, with a sub-surface conductor. The Brush company, of Cleveland, are supplying the electric machinery.

MANUFACTURING AND TRADE NOTES.

THE GEO. F. CARD MANUFACTURING Co., Cincinnati, Ohio, are prepared to supply electric motors of small and moderate size for use on electric light circuits or with batteries. Their handsome catalogue contains a description of the distinctive features of their motors, with illustrations, setting forth several features of interest.

THE ELECTRIC GAS LIGHTING Co., of Boston, are having a large demand for their new "single magnet" ratchet burner. It is extremely simple in construction, and direct in action, with very small liability to disarrangement. It is highly commended for use in houses, banks, stores, etc. The manufacturers regard its principles of construction as affording the only safe and sure method of turning gas on and off, and igniting it simultaneously by electricity. The company are also manufacturers and wholesale dealers in all styles of electric goods, lighting apparatus and electrical appliances in general.

THE WATERHOUSE ELECTRIC AND MANUFACTURING Co., Hartford, Ct., have doubled their capacity for the production of electric light apparatus, and are very busy on orders.

Among the recent installations and orders received for arc lights are The Waterhouse Electric Co., Baltimore, Md., 500; The Newark Schuyler Electric Light Co., Newark, N. J., increase 100; The People's Electric Light and Power Co., Wellsville, Ohio, 60; The Fredericton Electric Light Co., Fredericton, N. B., 66; Fresno Gas Co., Fresno, Cal., increase 30; W. C. Clark, San Francisco, Cal., 75; H. N. Green, Cadillac, Mich., 70; Taft, Weeden & Co., Providence, R. I., 33; Slater Cotton Co., Pawtucket, R. I., 30; E. Jencke's Mfg. Co., Pawtucket, R. I., 83; Washington Gas Co., Washington, Ind., 30; Jarecke Mfg. Co., Erie, Pa., 33; The Billings & Spencer Co., Hartford, Ct., 25; Forest Fibre Co., Berlin Falls, N. H., 30; Messrs. R. & H. Simon, Union Hill, N. J., 70.

MESSRS. SHAW & GEARY, of Philadelphia, have established a going and growing business in the manufacture of electrical appliances. They give particular attention to gas lighting, annunciator, and signal apparatus generally. Mr. Geary is a mechanic of a high order, and has had large experience in electro-mechanical work in prominent establishments. The catalogue of the firm exhibits several specialties of interest to the purchasers of electrical supplies.

MESSRS. JAMES W. QUEEN & Co., of Philadelphia, have added to their large list of scientific apparatus, the new electrical balances of Sir William Thomson. These instruments are manufactured by the celebrated James White, of Glasgow, and Messrs. Queen & Co. have been made sole agents for their [illegible] in the United States. The firm has for many years given spe[illegible]tention to supplying high class physical apparatus for educational, laboratory and practical use; and they evince their intention to keep abreast with progress in arranging so promptly to supply American electricians with Sir William Thomson's latest contribution to their metrical apparatus.

THE WATERHOUSE ELECTRIC AND MANUFACTURING Co., of Hartford, Conn., have been awarded a gold medal for their system of arc lighting on account of tests made of their apparatus at the Mechanic's Fair, Boston, just closed. The judges report is highly commendatory to the Waterhouse system, and special mention is made of the Waterhouse regulator. The Waterhouse system is being rapidly introduced. The company have doubled their capacity recently, and are installing many plants.

THE ANNUAL MEETING of the stockholders of the Westinghouse Electric Co., of Pittsburgh, was held in the offices of the company, in that city, on Friday, Nov. 25. The reports submitted to the stockholders showed that the affairs of the company were in a satisfactory condition, and the outlook for the coming year is exceedingly bright. Since April 1, 80 plants have been supplied, with an aggregate of over 108,000 lights, and there are contracts in hand for almost as many more. The company now employ about 1,000 persons, and when the new buildings are completed and occupied, by Jan. 1, next, this number will be almost doubled. The earnings of the company thus far in 1887 have been in excess of 10 per cent. on the capital of $5,000,000, and are steadily increasing.

THE ABENDROTH & ROOT MANUFACTURING Co., 28 Cliff street, N. Y., have recently closed contracts for Root's Sectional Safety Boilers, with the Edison Illuminating Co. of Detroit, Mich., First Cincinnati Edison Illuminating Co., Cincinnati, Ohio, Jersey City Electric Light Co., Jersey City, Brush Electric Light Co., Louisville, Ky., Columbus Edison Electric Light Co., Columbus, Ohio, and the Edison Electric Light and Power Co., St. Paul, Minn.

THE AMERICAN INDURATED FIBRE Co., Mechanicsville, N. Y., are finding demand for their patent wood fibre pipe, for gas and water distribution, and for underground electric wires. The pipe is manufactured from long wood fibre, specially prepared by separation of the wood and fibres, and thoroughly washed and freed from saps and gums; while in this pulpy state it is carried into forms, and, by enormous hydraulic pressure, is shaped into pipe. The pipe, after being thoroughly saturated with a special chemical mixture, is baked in a very high temperature. It is said to become strong, hard, and impervious to acids and moisture, and absolutely water-proof and proof against decay, and practically indestructible.

THE OKONITE Co. have issued a new circular and price-list for 1888. The Okonite insulation has become well and favorably known among electricians. The products of the company, as set forth in their catalogue, cover a wide range of uses—from submarine cables to single wires as small as No. 24 B. W. G. Particular attention is given to supplying electric light conductors.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions,* 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From Nov. 22d to Dec. 13th., 1887 (inclusive).

Alarms and Signals:—*Electrical Indicator for Weighing Scales*, J. E. Tarbox, 374,013, Nov. 29. *Electric Temperature Indicator*, J. C. Boyle, 374,581, Dec. 13.

Conductors, Insulators, Supports and Systems:—*Insulating Joint or Pipe Coupling*, E. F. Gennert, 873,452, Nov. 22. *Manufacture of Telegraph and Other Poles or Posts*, D. Wilson, 374,103, Nov. 29. *Apparatus for Covering Wire with Soft Metal*, J. C. Appleby, 374,164, and 374,166. *Conduit for Cable or Electric Railways*, W. Nier, 374,315. *Underground Conduit for Electrical Conductors*, G. W. Cook, 374,348. *Underground System for Electric Wires*, J. P. Davis, 374,458, Dec. 6. *Conduit for Electric Conductors*, E. E. Greene, 374,738, G. D. Holt, 374,792, Dec. 13.

Clocks:—*Electrical Horometer*, B. M. Hammond, 373,975, Nov. 29.

Distribution:—*System of Electric Distribution*, M. Waddell, 374,381, Dec. 6.

Dynamos and Motors:—*Dynamo Electric Machines*, T. A. Edison, 373,584. *Prevention of Sparking in Electric Motors and Generators*, D. Highen, 373,739, Nov. 22. *Regulation for Electric Generators*, R. P. Sellon and W. M. Mordey, 373,859. *Winding Armatures of Dynamo-Electric Machines*, C. E. Scribner, 373,948. *Commutator-Connection for Dynamo-Electric Machines*, J. W. Easton, 373,971, Nov. 29. *Electric Motor or Dynamo-Electric Machine*, F. J. Patten, 374,621. *Armature*, H. B. Slater, 374,711. *Dynamo-Armature*, E. N. Bliss, 374,728. *Electric Generator and Motor*, A. F. Congdon, 374,778. *Dynamo-Electric Machine*, G. Westinghouse, Jr., H. M. Byllesby, O. B. Shallenberger, A. Schmid, and B. Hartley, 374,858. *Electric Motor*, W. Hochhausen, 374,871. *Apparatus for Reversing and Controlling Electric Motors and Other Translating Devices*, same, 374,872. *Regulation of Electric Motors*, W. Stanley, Jr., 374,910, Dec. 13.

Galvanic Batteries:—*Galvanic Battery*, H. Brewer, 373,435, Nov. 22, H. E. Waite, 374,329, F. J. Crouch, 374,456, Dec. 6, J. Serson, 374,631, J. Freeman, 374,668, J. A. Barrett, 374,863. *Electric Battery*, same, 374,862, Dec. 13.

Ignition:—*Electric Gas-Lighter*, J. B. Entz, 374,528, Dec. 6.

Lamps and Appurtenances:—*Electric Arc Lamp*, G. A. Wiese, 373,761, Nov. 22. *Application of Accumulators to Electric Lighting*, T. P. Conant, 373,883. *Electric Arc Lamp*, C. A. Homans, 373,984. *Arc Light*, C. B. Noble, 374,129, Nov. 29. *Incandescent Electric Lamp*, M. Wheeler, 374,224, Dec. 6. *Method of Testing Electric Lamp Globes*, C. F. Reinmann, 374,850, Dec. 13. [illegible] *for Measuring Electric Currents*, H. Aron, 374,860, and 374,[illegible]

Medical:—*Electro Medical Apparatus*, J. S. Muir, 374,7[illegible], Dec. 13.

Miscellaneous:—*Feed-Water Heater*, C. W. Fowler, 373,520. *Electric Coupling*, G. W. Taylor, 373,759, Nov. 22. *Automatic Circuit-Opener*, J. P. Tirrell, 374,017. *Electric Door-Opener*, A. C. Woehrle, 374,028. *Circuit-Closer*, B. R. Bosworth, 374,436. *Electric Temperature Regulator*. W. S. Johnson, 374,072. *Eectric Organ Action*, H. L. Roosevelt, 374,088. *Paper Cylinder for Graphophonic Records*, C. S. Tainter, 374,133, Nov. 29. *Apparatus for Converting Heat Energy into Electrical Energy*, W. E. Case, 374,173. *Electrical Dental Engine*, G. W. Whitefield, 374,225. *Electric Governor*, W. H. Reynolds, 374,374. *Regulator for Electric Currents*, S. D. Field, 374,404. *Regulation of Electric Generators*, D. Higham, 374,406. *Coin-Operated Induction Coil*, W. R. Pope, 374,495, Dec. 6. *Revolving Electric Hammer Tool*, W. G. A. Bonwill, 374,580. *Electric Fuse*, K. J. Sundstrom, 374,640. *Circuit-Breaker*, C. B. Bosworth, 374,652. *Safety Strip for Electric Circuits*, P. Lange and O. B. Shallenberger, 374,842. *Electric Coupling Device*, P. Lange, 374,843. *Electro-Mechanical Movement*, H. Van Hoevenbergh, 374,883. *Wire-Splicer*, W. F. Batten, 374,650, Dec. 13.

Railways and Appliances:—*Electric Railway*, E. M. Bentley, 374,736. *Rail-Connection for Electric Railroads*, E. L. Orcutt, 374,199, Dec. 6. *Railway-Switch*, S. C. C. Currie, 374,733, Dec. 13. *Contact-Brush*, E. L. Orcutt, 374,198, Dec. 6.

Storage Batteries:—*Automatic Circuit-Closer for Secondary Batteries*, W. W. Griscom, 374,673, Dec. 13.

Telegraphs:—*Printing Telegraph*, C. J. Wiley, 373,508, Nov. 22. *Induction Telegraph System*, G. T. Woods, 373,915. *Telegraph-Pole Protector*, H. P. Copeland, 373,925. *Telegraphy*, P. B. Delany, 373,967, 373,968. *Telegraph Instrument*, C. G. Burke, 374,038, Nov. 29. *Telegraph Transmitter*, A. Bixby, 374,390. *Printing Telegraph*, same, 374,444, Dec. 6.

Telephones, Systems and Apparatus:—*Telephone Apparatus*, I. H. Farnham, 373,519. *Device for Attaching Tablets to Telephone*, H. H. Butler, 373,767, Nov. 22. *Mechanical Telephone*, J. P. Sunderland, 373,862, *Telephone Call-Box*, C. E. Scribner, 373,910, Nov. 29. *Transmitter*, R. W. Whitney and F. Pultz, 374,439, Dec. 6. *Multiple-Switch-Board Test-Circuit*, C. E. Scribner, 374,907, Dec. 13.

THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS, JR.

PUBLISHED MONTHLY BY

THE ELECTRICAL PUBLISHING CO.,

115 Nassau Street, New York city.

European Agent, F. H. WEBB, 4, The Sanctuary, Westminster, London, S.W., Eng.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
One Copy, Four Months,		1.00
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies,		.30

[*Entered at the Post Office at New York, N. Y., as second class mail matter.*]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of the* ELECTRICAL PUBLISHING CO. *Communications for the attention of the editors should be addressed*, EDITOR OF THE ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

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NEW YORK, FEBRUARY, 1888.

We are pleased to renew our announcement of last year that by arrangement with the ELECTRICAL WORLD, *we are able to offer that excellent weekly journal in conjunction with* THE ELECTRICAL ENGINEER, *for one year to new subscribers for* $5.00. *To those of our present subscribers who desire it we will supply the* ELECTRICAL WORLD *one year for* $2.50

MR. EDISON ON PATENT PROTECTION.

THE unthinking and unintelligent members of the body politic who are clamoring for the overthrow of our patent law, under the wholly mistaken impression that the consummation of their design would in some unexplained way, aid in the suppression of their pet bugaboo, "monopoly," have received a notable recruit to their ranks in the person of one of the principal beneficiaries of the system which it is proposed to destroy. Ordinarily, the right of a private person to the unmolested enjoyment of his own opinions in respect to this or any other subject is not to be questioned, but when an inventor occupying so prominent a position before the public as Mr. Edison, appears on record as an exponent of the opinions attributed to him in the published interview which we reprint in another column, his action ought not to pass without comment. Mr. Edison is reported as saying :—

The present law is a constant temptation to rascals, and virtually offers a premium upon rascality; under it the infringer of a patent is not interfered with until the real owner can show that he has the monopoly of the device in question. This process may take years, during which the infringer who has money and audacity enough to seize another man's invention can go on and perhaps wear the rightful owner's life out by litigation and annoyance. I have had so much of this sort of thing within the last five years that I have almost made up my mind never to take out another patent until the law is changed. The burden of proof is now put entirely upon the man who holds the patent, instead of upon the man who wishes to infringe it, whereas it ought to be all the other way.

An old proverb bids one to speak well of the bridge that has carried him safely across the stream. It is not many years since Mr. Edison was earning, by diligence and industry, a modest stipend of some three dollars per diem as a telegraph operator, and it is but just to say that he was accounted a very skillful one, and well worth the money. To-day he occupies the finest estate in the vicinity of the metropolis, and if he is not twice a millionaire, it can be for no other reason than that like too many of the rest of us, he has found it less easy to keep money than it is to get it. We venture to assert, that had it not been for the patent law, which he now decries, Mr. Edison would, in all human probability have been "pounding brass" as the phrase is, at this moment, although it is doubtful if in the absence of the inventions, which the patent law has fostered, anybody could afford to pay him more than $1.25 per day. Who would have given him a dollar in exchange for his quadruplex and automatic telegraphs, and his electric light inventions, had it not been for the patent law? Would he not have been obliged to content himself with the modest wage earned by daily industry? He adds, mysteriously :—

I have already found one chemical device which promises to pay me handsomely, and the Patent Office will never hear anything about it; to apply for a patent would simply invite a lot of rogues to share with me, or, what is more likely, to take all the profits.

Every right-minded person will be gratified to learn that the prospects of Polyform, if indeed it be that excellent remedy which is referred to, are so flattering. But to return to the patent law. Mr. Edison complains :—

There is scarcely an invention of importance made within the last generation which has not been disputed upon frivolous grounds, and the inventor put to all sorts of annoyance. In my own case, I am sure that no matter what I may patent, some one will come up as soon as the patent is seen to have any value and show by dozens of witnesses, if necessary, that he is the rightful owner of the invention. If I patent to-morrow a process for making good flour at a cost of two cents a barrel, the publication of my patent would bring out about 10 men who could prove that they did that sort of thing years ago, and that I had no right to a patent.

This is not simply an indictment of the patent law, but of all law whatsoever, and the real root of the trouble obviously lies, not in the statutes, but in that inborn proclivity of the unregenerate human animal which prompts him to appropriate his neighbor's property, and which it is one of the principal functions of the common law to prevent and punish. The patent law merely serves to protect the inventor by declaring that an invention is property, and that it may, therefore, be the subject of larceny.

The federal courts have never to our knowledge, pronounced any patent whatever invalid, because of prior knowledge or prior use by another, except the anticipating invention had been actually embodied in a concrete and operative machine or method, and that fact had been proved beyond a reasonable doubt. That the law is designed to protect, and that it does in fact protect, the real originator, is abundantly shown in the cases of such inventors as Goodyear, Howe, Morse, Bell, Edison, Westinghouse and many others, whose achievements have served to render the annals of American industry illustrious.

The fact is, and it is well to bear it in mind, that the

pre-eminence of the United States, as distinctively a nation of inventors of improved machinery and processes, dates back no further than the patent law of 1836, which is substantially the one now in force, and it is to the fostering care of this wise statute, more than of any other which has ever been enacted by Congress, that this country owes its present prosperity and greatness.

Do not lay rash hands on the patent law. Let the American inventor be protected. *In hoc signo vinces.*

POST-OFFICE TELEGRAPHY.

WHILE it is somewhat unlikely that a bill for the assumption of the telegraph business of the country by the Government will be matured and acted upon by Congress during the present session, the project is again receiving a good deal of attention, both in and out of the National legislature, and will doubtless, at no very distant time, come up for adoption or rejection. Our Washington correspondence describes a number of schemes proposed by members of Congress.

The question was very fully considered at Washington some fourteen years ago at the instance of the Hon. Gardiner G. Hubbard, when a postal telegraph was energetically opposed by the Western Union Telegraph Co. before Congressional committees. The expediency of the measure then before the country received a prolonged and voluminous discussion in the public press; advocates and opponents of the scheme brought forth and spread before the country exhaustive collections of facts, figures and arguments till, it is safe to say, nothing was left undone to enlighten the judgment of legislators and the public. The promoters of the project were vigorous and persistent in the advocacy and prosecution of their plans, but failed of success.

In current and future agitation of the subject it seems probable that abstract or constitutional objections will count for little, and that discussion will be concentrated chiefly upon economic considerations, or in other words, the expediency of a post-office telegraph system for the service of the public.

Whether or no the pendency of this question and the certainty that it would be brought forward from time to time have served to stimulate the Western Union Telegraph Company in improving and cheapening their service, the receipts of that company per message have been reduced, since 1874, from 56 cents to 30 cents (say 46 per cent.), whilst their facilities—miles of poles and wire and number of offices—have been much more than doubled. When, before the Senate Post-Office Committee, January 20th, Dr. Norvin Green, president of the Western Union Company, distinctly pledged that corporation not to increase the rates of the past year, and promised further reductions during the current year.

COPPER.

THE extraordinary advance in the price of copper which has taken place within the past few months, still continues, and cannot fail to affect electrical interests seriously, if present prices are maintained for any considerable period. While it is true that the present figure of 16 to 18 cents is not very high compared with the quotations between 1865 and 1875, which ranged from 20 to 30 cents, yet it is an advance of 60 to 80 per cent. on the lowest figure reached in 1887, and entering so largely as it does, into the entire cost of an electric lighting or power plant, is certain to make a very material difference in the price which the purchaser will be obliged to pay. The entire movement is apparently due to the operations of a French syndicate, which started out some months since to "corner" the copper market of the world. The fire in the Calumet and Hecla mine, the principal source of the American copper supply, occurred just in time to aid the projectors of this scheme in its successful consummation.

Everything indicates that the price of copper will be forced higher and higher, until, in the slang of the exchanges, "the bottom drops out," when in all probability the price will fall with startling rapidity to a point in the neighborhood of 12 cents. Meantime manufacturers of electrical copper goods are pursuing a cautious and conservative policy, and buying only as fast as needed, so that, by means of frequent revisions of their discount lists, they may be able to avoid any serious losses. The present movement appears to be purely speculative, and it is not probable that the present high prices can be maintained for any great length of time.

If the advance in the price of copper prove to be more than temporary in its effect, one of its incidental results will be to handicap seriously the low potential systems of electrical distribution, in their efforts to compete commercially with the high potential systems of more recent introduction.

AMERICAN readers of English electrical journals have doubtless observed with some surprise the large measure of attention that has been secured in Great Britain during the past year or two by exploiters of various primary batteries for electric lighting; attention not only of electricians but of investors as well. There is no evidence of any substantial successes in the use of primary batteries for the supply of current in large quantities; nor do we believe that any success has been looked for by well-informed electrical engineers. One or two efforts in the same direction have been made here, but they attracted relatively small attention in electrical circles, and the enterprises founded upon them seem to have made but little headway. Without some radical and revolutionary discovery in chemistry there appears no reason to expect the cost and inconvenience of primary batteries to be brought within practicable limits for lighting or power currents.

WE have been favored with a copy of the "Report of the Commission to Investigate and Report the Most Humane and Practical Method of Carrying into Effect the Sentence of Death in Capital Cases," presented to the New York Legislature, January 1st. The gist of the report is contained in the recommendation that Section 505 of the Code of Criminal Procedure be amended to read as follows:

> § 505. The punishment of death must, in every case, be inflicted by causing to pass through the body of the convict a current of electricity of sufficient intensity to cause death, and the application of such current must be continued until such convict is dead.

It is difficult to imagine any reasonable objection to the

proposed substitution of the dynamo for the gallows. Further recommendations of the Commission in respect to the time, place and privacy of executions are clearly in the interest of public decency and order.

It is not easy to comprehend why the Commission should have seen fit to precede their suggestions by an historical sketch of all modes of capital punishment, ancient and modern, including horrors that would better be left to the ken of special students only.

The index of current electrical literature, dating from October, begun by the Institute of Electrical Engineers in the monthly volumes of transactions for December and January, will be highly appreciated by all who have occasion to consult such literature. The work has been very carefully done, and greatly enhances the value of the published volumes of the Institute. It has been suggested that it would add to the usefulness of the index to print it on only one side of the pages, thus enabling those readers who make card catalogues to do so conveniently without copying. There would be no objection, in such cases to cutting up the monthly installment of the index, as it is, we believe, intended to re-print the whole in each yearly volume.

This index is but another example of the devotion of the President and Secretary to the work of the Institute. They have given their time and service without stint for the promotion of its interests. It is very gratifying to observe the large growth of the society during the current year, not only in numbers, but in character and influence.

The National Electric Light Association will hold its Annual Meeting at Pittsburgh, February 21–23. The importance of many recent developments in the art and business of electric lighting, together with the central location of the place of meeting, will doubtless secure a large attendance of members and others. Pittsburgh affords an excellent opportunity for the inspection of alternating current plants in operation, there being several such in the immediate vicinity. It seems to be understood that the measures initiated by the Association for obtaining from Congress the appointment of a Commission to revise the patent system will come up for further discussion and final action at the Pittsburgh meeting.

Mr. C. A. Brown's paper on Revision of the patent law, read before the Chicago Electric Club, January 16, and which we print elsewhere in this issue, offers very weighty reasons against the project of the National Electric Light Association. Mr. Brown looks at the matter from the point of view of a careful student of legal questions as well as of a man of business intimately acquainted with the relations of patents to manufacturing enterprises. His consideration of the proposed creation of a commission to overhaul the entire patent system has led him to conclusions much in accord with the views expressed by the Electrical Engineer in December. Mr. Brown sees good reason for apprehension lest an attempt at a general revision by a commission may lead to results quite the reverse of those desired by the advocates of reform in the patent system.

There can be little doubt that, with very few exceptions, electrical manufacturing and construction companies and firms still carry on their work with insufficient attention to scientific and technical, not to say economical principles. There seems to exist in many quarters a deep-rooted aversion to the recognition and employment of highly trained technical talent in the design and construction of electrical plants for light or power. The American instinct to trust to gumption and cuteness prevails largely in electrical circles. The attitude of some enterprising "practical" manufacturing and construction concerns towards trained electrical engineering skill, reminds us of the convocation of local magnates in a frontier town of considerable size, that had grown up in a few months, and who explained the absence of a church to an eastern capitalist, conferring with them about the further development of the business of the place, by saying that "they had thought of starting a church" but after due deliberation had concluded "it would look too dudish."

The charges of the Electrical Engineer for editorial advertising are placed at so high a figure that we seldom have an opportunity to earn an honest penny thereby. In the present instance we look for no remuneration beyond the sense of rendering service by announcing the discovery of a unique and valuable servitor awaiting the call of those who perhaps know him not. An electrical corporation permits us to copy the following communication, received by them in the course of business:—

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Every man has his forte.
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Yours, faithfully,

Should any of our readers who distrust their own ability to set forth adequately the pre-eminent merits of their wares or undertakings desire the assistance of this ready-writer, we shall be pleased to use our best efforts to obtain permission to furnish his name and address.

In the comments upon electrical litigation in the editorial columns of The Electrical Engineer for January, an error was made in the paragraph referring to the suit of the Thomson-Houston company against the American company for infringement of patent. The patent upon which the suit is based is No. 238,315, to Thomson and Houston as joint inventors, and not, as stated in the article referred to, "Professor Thomson's patent."

ARTICLES.

DISCUSSION OF THE PRECISION OF MEASUREMENTS.[1]

BY SILAS W. HOLMAN.

In quantitative measurement of any kind, and more obviously in physical work, but little progress can be made before questions respecting the precision of the results, and of the component measurements which go to make up those results, thrust themselves upon the observer. For simple, direct measurements, it may suffice to state in a few words the process of averaging and of inspecting the concordance of the measurements. These, with proper allusions to instrumental errors and their elimination, would at least readily satisfy the demands of all but quite advanced students. But, in fact, few physical, and almost no electrical measurements are direct, if we except such commercial work as corresponds in grade to the measurement of cloth with a yard-stick. For instance, a student is set to determine the specific electrical resistance of a sample of wire. He has, we will say, to measure the length, weight and resistance of the wire, its temperature, and that of the resistance box by which he measures. The thoughtful student will ask himself at once how closely each of these quantities must be measured, in order that he may get the final result with the desired closeness. He will appreciate, especially if he has previously done physical or chemical work, that not only must all the quantities be measured with some care, but that each will have its own special requirement as to grade of accuracy, which ought to be known in advance of his final observations, and which *must* be complied with if the desired final accuracy is to be reached. Thus in careful work, even when not of a high grade, and in qualitative as well as in quantitative study, it is essential to predetermine the necessary conditions in the component parts of the work; that is to arrange or select the instruments for giving the most favorable conditions for the work, to proportion aright the parts of the instruments, to distribute properly the precision of the component measurements. And finally, less important in reality but ordinarily made more conspicuous, we should know how to form a numerical estimate of the reliability of the final result from the precision and nature of the component measurements which go to make that up.

The lecture course, of which the following pages contain the chief portions of the notes, was arranged with such thoughts as the foregoing in mind. Its direct object is to present to students somewhat advanced in electrical measurements, a systematic method by which such inquiries might be investigated; to illustrate this method by a number of original investigations worked out in detail; and to present some problems for solution. The demands of the course did not render an exhaustive treatment imperative, so that the notes have not always been thrown into the most general form. But it is thought that they contain enough to serve as a basis upon which a competent student may solve any questions of this nature which he may ordinarily meet. The course assumes a knowledge of the differential calculus, and some acquaintance with the theory of probabilities, and the principle of least squares —subjects which in the order of these topics at the Institute precede the present one.

Given the result of an investigation or measurement of any kind, the first inquiry in regard to its quality is, or ought to be, what degree of confidence can be placed in it. In general, of course, the true value is unknown, and the above query can be answered only by statement of the probable accuracy of the result—for which it is necessary to find some numerical measure. It means nothing to the careful worker to be told that a given numerical result is "very accurate," or "quite accurate," etc., because he is aware that these terms have to different persons wholly different meanings. A numerical measure is essential. How can this be found?

It is obvious that an answer may be framed in this way: let the same quantity be measured many times, by many wholly distinct processes, and by many independent observers. The average, or arithmetical mean of all these results will be likely to approach the truth, and to come closer to it as the number increases. For we may assume, with a high probability, that exactly the same sources, magnitudes, and directions of error will not occur uniformly in all the results, but that there will probably be many errors, some +, some —, and of graded magnitudes, which, in the process of averaging, will tend toward the complete canceling of one another. Then the real error of any one of these independent results would be approximately given by its deviation from the average or mean result. It is, of course, very unusual to be able to command such series of measurements; but on that account it remains even more necessary to be ordinarily able to obtain an *estimate* of accuracy, and the method for doing so must therefore be developed.

For clearness, let us agree upon the following use of terms, and review some points concerning the nature of measurement and errors.

Let the term *precision* be used only with reference to the accordance of the individual results of a series; *i. e.*, their agreement among themselves or with the value adopted to represent the series, but without any reference to the possible divergence of the result from the truth.

Let the term *accuracy* be confined in its use to the latter case; *i. e.*, where it is desired to hold under consideration the observed result as a representative of the *true* result, or as differing from it. The *accuracy* of a result would then be under consideration when its *errors* were referred to (*i. e.*, observed minus true values); but in dealing with *deviations* of single results from the mean or representative result or from each other, only the *precision* would be under consideration.

Direct measurements are those made in such a way, or by aid of such instruments, as to obtain directly the quantity sought; *e. g.*, measurements of distance by a scale, of weights with a balance, of resistance with a bridge, etc. The direct readings may or may not require corrections.

Indirect measurements are those where the desired result is not given directly by the measurement, but as the result of some combination of several observed values of different quantities,—in other words, where the result is a function of the observed quantities; *e. g*, measurement of a distance by geodetic triangulation, of current by a tangent galvanometer or electro-dynamometer, of battery electromotive force or resistance by two deflections on a tangent galvanometer, etc.

Quantities subjected to measurement may be either *independent* or *conditioned*. That is, two or any number of quantities may be wholly independent, so that the magnitude of one is in no way predetermined by any relations to the others; or they may be conditioned so that, for instance, the magnitude of two out of three being given, that of the third is thereby predetermined. Thus the current flowing through a given resistance might be anything whatever, according to the potential used, so that measurements of current and of resistance at any instant would be independent. But if the potential difference at the ends of the coil were simultaneously measured, then the three, current, resistance, and potential, would be conditioned by Ohm's law. The numerical values obtained in the measurement of conditioned quantities contain, of course, errors not controlled by these conditions, so that the values fail to fulfill the conditions, and require adjustment.

Every measurement, of whatever sort, is subject to errors. In coarse work it is easy to bring these within the limits allowable; in fine work, difficult or impossible. The sources of error may be regarded as of two classes, determinate and indeterminate.

1. From *Technology Quarterly*.

Determinate sources of error. In any given investigation, a study of the instruments methods, and conditions of observation employed in the light of all accessible knowledge in regard to these will reveal many possible sources of error, whose effects may be determined with greater or less closeness. Corrections may then be applied therefor, or the instruments, processes, and conditions so modified as to eliminate them. Such sources of error would exist in the rate of a clock, in the graduation of a scale or circle, in the weights or beam of a balance, in the shape or adjustment of the coils of a galvanometer, etc. The study of these determinate errors is the most laborious part of an investigation, and is absolutely essential to even coarse work. Its neglect is repeatedly apparent in contradictory, and often useless results of elaborate work. But at the best, the correction and elimination of errors can be seldom more than approximate, and must leave behind residual errors, of greater or less magnitude, which will belong to the class of iudeterminate errors; yet the attempt should always be made to render these residuals so small as at least not to exceed the average of the variable indeterminate errors. A general consideration of the nature of corrections, and of the closeness with which they should be determined, will be given later.

Indeterminate sources of error. Apart from the recognizable and determinate sources of error, there is a large number of unrecognizable, or at least indeterminate sources. To the nature of these, careful study may fail to give any clue. We only know that between successive measurements by the same process and between the results obtained by processes entirely or partly independent, discrepancies are always found. This demonstrates the perpetual existence of these indeterminate disturbing sources. They are thus indeterminate not in magnitude and sign only, but often in nature also. Some, however, are of known origin, but are not determinable on account of their small magnitude or of our inability to sufficiently control or measure their effects.

It is obvious that these indeterminate errors, in some degree, counterbalance each other; but there is always liability in any particular case to a preponderance of a single or resultant disturbing effect, which no process of averaging or combining the separate results can eliminate. Thus there will in general be a residual indeterminate error, which may be, and often is, surprisingly large. Such an error being naturally of a nearly constant amount (often called "a constant error"), would *not* be rendered apparent by the deviations among the single results. Hence the *precision* measure (p. 46), *i. e.*, the measure of concordance of the results, would give no intimation of its existence, and is, therefore, never a true *accuracy* measure. The only hope of a sufficient elimination of indeterminate errors lies in the plan already suggested—of combining *many* results obtained by *many distinct* methods and observers.

Corrections. The process of determining the amount of a correction is in itself, or involves, a subsidiary investigation. It may consist of such an operation as comparing a scale with a standard, of determining the rate of a clock, of computing the effect due to the size and form of galvanometer coils, or to the short length of the mercury column in the exposed stem of a thermometer, etc. Few corrections can be found with absolute accuracy; in most cases the correction is determined by some physical process which will yield results of a desired accuracy, but will itself be subject to sources of error, which, in their turn, must be properly eliminated, and so on. Thus the study of the correction must be carried out under such conditions as to insure that its determinate errors have been so far removed that their residuals, in their turn, may properly be classed among the indeterminate errors. As to how small the precision measure of the correction should be rendered when all recognizable sources of error have been removed, it may here be said that this will be determined by two things,—the precision desired in the main result, and the labor involved in ascertaining the correction.

From this, it is obvious that if it were necessary in an investigation to work out from the beginning every detail of the research, establishing all standards, ascertaining all corrections, developing every process employed, the labor would be enormous—as, indeed it often is. But fortunately the progress of experimental science has provided instruments, processes, methods, and results of known accuracy, which may be appropriated in any desired manner in more complex investigations.

Deviations vs. Errors. What is known of the laws *of error* is purely the result of inference. True values are never absolutely known. Let a_1, a_2, etc., be single observations of a quantity of which the true value is R. Their errors would be $E_1 = a_1 - R$, $E_2 = a_2 - R$, etc., but these cannot be known as R in unknown. Let A be the value chosen as the best representative (*e. g.* arithmetical mean) of the series. Then we know $d_1 = a_1 - A$, $d_2 = a_2 - A$, etc., which may be called the *deviations* of the single results from the best value, however that may be arrived at. The laws of these deviations have been studied for many different series of actual measurements. They are not the same for all cases. The following is, however, the most general case, and that from which the law of "accidental errors" is inferred.

Suppose an *indefinitely large number of equally careful* observations of a quantity made in a great variety of ways, and under widely different conditions: prolonged experience shows that the deviations of the single observations from the mean, in such a series, are distributed according to a definite law, which is approximated to more closely as the number of observations is greater, and which may be represented by an exponential equation. Of this distribution, it may be said that + and — deviations of any given magnitude are equally frequent; that small deviations are more frequent than large ones; that very large ones occur very seldom.

In such a series we should readily admit that sensibly all sources of *error* must have occurred in all possible ways. If so, we should suppose from the laws of chance, considered purely from a mathematical standpoint, that probably + and — errors of any given magnitude would be equally frequent, that small errors would be more frequent than large ones, and that very large errors would occur very seldom. But these statements are identical with those just found actually to hold for the deviations from the mean in the same series. Thus, *for such a series, the deviations may be assumed as sensibly coincident with the errors, and the mean with the true result,* which justifies the statement made at the outset (p. 44).

Best representative value. But the indefinitely large series is, of course, unattainable in practice, when the number of observations must generally be small. For smaller series the distribution of the *individual results about the mean* may be (usually is) approximately the same as for large series,—more closely as the number is larger, but as already stated in other words, we have no assurance that the deviations are accidental *errors*, as the mean may be, and very likely is, affected by some considerable resultant or constant error. The process of averaging *tends* to the elimination of the variable parts of the errors; and it may therefore be shown by the theory of probabilities, or experimentally, that even for small series the arithmetical mean is the best representative value, *provided that determinate errors have, as far as discoverable, been removed.* That is, the mean is the most probable value,—the one which in the long run will give the closest approach to the true result. Since the mean and true result will generally not coincide, there will be residual errors. These will themselves, in the long run, be distributed according to the general law of accidental errors, which is another indication that the mean is the best value to use. For that would naturally be the best value which, in the long run, would so distribute the residuals that their algebraic sum would be zero.

It thus appears that in order to get at a measure or

estimate of the accuracy of the result of a completed investigation, we must study, first, all discoverable sources of error, in order to ascertain how far those which are determinate have been corrected or eliminated. Second, we must compute a measure of the disturbance due to the *variable portion* of the remaining indeterminate sources of error, so far, at least, as the measure of precision (below) will give this. But it must always be remembered that beyond all this there *may*, and in general *must*, remain undetected "constant" errors. The discussion of the determinate errors is by far the most important of the two points above referred to. The discovery of an undetected source of error in a result, furnishes, of course, a means of estimating its minimum error, or possibly of correcting it. If several measurements of the same quantity by different processes and observers exist, then the study of each, and the comparison and combination of all, will furnish the best available means of estimating the accuracy of the knowledge regarding that quantity.

The ideal procedure in a quantitative investigation would be this: Make a preliminary survey of the ground to be covered. Then make a detailed survey, and map out the general method and theory of the work. This includes studies of the apparatus to be used; of the procedure in observing; of the method of computing or "reducing" the results (the importance of having this thoroughly worked out in advance is very great); of the determination of the conditions under which the observations are to be made; of the distribution of accuracy necessary in the component measurements; of the nature of the instrumental and other corrections; of the best means of obtaining check results, etc. Next would come the preliminary observations of evaluating, *i. e.*, determining the value of, the corrections, etc. Then come the measurements proper of the investigation. Finally, there is the reduction, discussion, and presentation of these results. These last include not merely a computation and tabulation of the numerical results, but a complete discussion of their significance, a critical review of the work, and a thorough presentation of the whole, with data, when practicable, sufficient for a re-discussion of the work by others.

Three points may be mentioned in which quantitative investigations often fail to satisfy reasonable demands. First, the theory of the method is insufficiently studied in advance of the measurements, so that the adjustment of accuracy in the various component parts of the work is faulty, and the determinate errors are incompletely eliminated. Second, the results are presented in a very imperfectly digested form, so that but a very small part of their proper outcome and significance is obtained. Third, the data and results are so meagerly given that it is impossible to form any independent judgment of the real merit of the work.

It is not superfluous to remark that the sole object of scientific investigation is the ascertainment of truth; and scientific work to be deserving of such classification must be conducted throughout in this spirit. The scientific observer must not only be above suspicion, but must be continually on his guard against bias and prejudice. Also, as the object of most investigation is to add to the known truth, it goes without saying that the worker should never fail to equip himself beforehand with a knowledge of all that has been previously done in the line of his proposed work. Independent corroboration of work is of very great value; but it is likely to be of greater value when done in view of, than when in ignorance of, previously existing work.

The topics and formulæ necessary for the discussion of the relative distribution of precision in the component measurements of a complex quantity, of the best conditinos for making certain measurements, and other analogous matter, will be now taken up, and illustrative examples will be given.

Measure of precision. Bearing in mind the denotation already fixed upon for the terms accuracy and precision, it will be understood that the precision measure can never be anything more than an index or measure of the accordance of the single observations in a series, or of the separate results (means or single observations) composing a group. For most physical uses the simplest and most direct measure of precision should be preferred, and this is the *average deviation.* In addition to simplicity of computation, this has the merit that its name states exactly what it is, and all that it is, and no more. It is free from the liability to mislead which embarrasses the use of such terms as "probable error," "mean error," etc., these being stumbling-blocks to beginners, and a frequent cause of misapprehension even to those who know the true meaning of the terms.

The *average deviation* of the single observations from the mean will be indicated by *ad.* This will denote the average *magnitude* of the deviations, and it may be computed by the formula

$$ad = \frac{\Sigma d}{n} \qquad \text{I.}$$

where, therefore, Σd is the arithmetical sum of the deviations without regard to algebraic sign. Since a mean result is more precise than a single observation in the proportion of the square root of the number of the observations from which it is deduced, we should have, as a corresponding measure of the precision of the mean,

$$A\,D = \frac{a\,d}{\sqrt{n}} \text{ or } = \frac{\Sigma\, d}{n\sqrt{n}} \qquad \text{II.}$$

which would be called the average deviation of the mean.

Instead of ad and $A\,D$ are often employed the "probable errors," which may be computed as

$p\,e = 0.674\sqrt{\frac{\Sigma d}{n-1}}$, or approximately 0.85 $a\,d$, or 0.9 ad,

and $PE = \frac{p\,e}{\sqrt{n}}$. The "error of mean square" $=$

$\sqrt{\frac{\Sigma d^2}{n-1}}$ has been employed to a considerable extent in Germany.

The formula for the average deviation for indefinitely large series of observations following *any* law of distribuion may be deduced thus:—

$\Delta =$ a deviation.

Let $\varphi(\Delta) =$ the law of deviation. The general law of deviations already referred to (p. 45) is not the only one; another is given further on in these notes. $\varphi(\Delta)$ is such a function that

$\varphi(\Delta)\cdot d\Delta =$ the probability that any single observation will have a deviation lying between Δ and $\Delta + d\Delta$; or $\varphi(\Delta).d\Delta =$ the "frequency" of occurrence of observations with deviations within that limit.

$n =$ total number of observations in the series.

$\therefore n\cdot\varphi(\Delta)\cdot d\Delta =$ *number* of observations with deviations between Δ and $\Delta + d\Delta$.

$n\Delta.\varphi(\Delta)\cdot d\Delta =$ sum of all the deviations between Δ and $\Delta + d\Delta$.

$\int_0^\infty n\Delta\cdot\varphi(\Delta)\cdot d\Delta =$ sum of all the deviations between $\Delta = \infty$ and $\Delta = 0$, *i. e.*, of all the positive deviations.

$$2\int_0^\infty n\Delta.\varphi(\Delta)\cdot d\Delta = \text{sum of magnitudes of the } n \text{ deviations.}$$

$$\frac{-}{n}\int_0^\infty n\Delta\cdot\varphi(\Delta)\cdot d\Delta = ad = \text{average of all the deviations between } +\infty \text{ and } -\infty, \ i.\ e., \text{ average magnitude.}$$

$$\therefore ad = 2\int_0^\infty \Delta\cdot\varphi(\Delta)\cdot d\Delta. \qquad \text{III.}$$

If the deviations range only between the limits $+a$ to $-a$

$$ad = 2\int_0^a \Delta\cdot\ \varphi(\Delta)\cdot d\Delta. \qquad \text{IV.}$$

In any individual case it is therefore necessary to know a and $\varphi(\Delta)$ in order to have a determinate expression for ad.

Special law of deviations. 1st. There frequently occurs in practice the case where all values of Δ between $\Delta = +a$ and $\Delta = -a$ are equally likely to be obtained; *i. e.*, are equally frequent. Then $\varphi(\Delta) =$ a constant. Bearing in mind that the sum of all possibilities must be always unity, and also the above definition of $\varphi(\Delta)$, we have $\int_{-a}^{+a}\varphi(\Delta)\cdot d\Delta = 1$. Remembering that $\varphi(\Delta)$ is constant, and integrating gives $\varphi(\Delta)\int_{-a}^{+a} d\Delta = 1$

$$= 2\,a\,\varphi(\Delta);$$

$$\therefore \varphi(\Delta) = \frac{1}{2a}, \text{ and } a\,d = 2\int_0^a \Delta\cdot\varphi(\Delta).d\,\Delta = \frac{a}{2} \qquad \text{V.}$$

2d. Two independent and simultaneous sources of deviation, each following the law of 1st case.

$$a\,d = \tfrac{2}{3}\,a. \qquad \text{VI.}$$

Other cases may arise. [Both the foregoing and this demonstration are from Wright's "Adjustment of Errors of Observation."]

Principle of least squares. From the general law of distribution of deviations, or accidental errors, two deductions of importance may be made, viz.:—

1. That in combining a large number of equally reliable observations, whether direct or indirect, and whether of one or several independent variables, the most probable, or "best" result will be that which makes the sum of the squares of the deviations from that result a minimum. This is called the principle of least squares, and finds wide application. The use of the arithmetical mean may be shown to be in accordance with this principle.

2. That of means deduced respectively from n_1, n_2, etc., measurements, all equally reliable, the relative precision is in proportion to the square roots of the number of measurements; that is, of $\sqrt{n_1} : \sqrt{n_2}$ etc. Thus the mean of n equally reliable results is more precise than a single observation in the proportion of $\sqrt{n} : 1$; and hence $AD = \frac{a\,d}{\sqrt{n}}$ may be used as the precision measure of the mean, as stated at p. 46.

If the measurements are not all equally reliable, they may be made so by the application of their respective weights. It is shown from the law of deviations, that the weights of observations are inversely proportional to their AD^2, PE^2, etc. Let p denote the weight, then

$$p_1 : p_2 : p_3 = \frac{1}{A\,D_1^2} : \frac{1}{A\,D_2^2} : \frac{1}{A\,D_3^2}$$

$$= \frac{1}{PE_1^2} : \frac{1}{PE_2^2} : \frac{1}{PE_3^2} = \text{etc.} \qquad \text{VII.}$$

In all the formulæ to be given, it will be assumed that the means and combinations are always made with due regard to weights.

Combination of changes in component measurements. Suppose an indirectly determined quantity, M, to be related to the several *independent*, observed quantities, M_1, M_2, . . . M_n, from which it is computed by the general expression

$$M = f(M_1, M_2, \ldots M_n, \qquad \text{VIII.}$$

Separate effects. 1st. What effect would a change δ or δ_2, etc., in any one of the variables M_1, M_2, etc., taken separately, have on M? It is obvious that this may be found from the differential of M with respect to M_1 or M_2, etc. Thus, for example, denoting for brevity, $f(M_1\ M_2, \ldots M_n)$ by $f(\ )$,

$$\frac{d\,M}{d\,M_1} = \frac{d}{d\,M_1}\Big(f(M_1, M_2, \ldots M_n)\Big); \text{ or}$$

$$\frac{d\,M}{d\,M_1} = \frac{d\,f(\,)}{d\,M_1}; \text{ etc.} \qquad \text{IX.}$$

For finite changes, δ or Δ, we have the approximation $\frac{d\ M}{d\,M_1} = \frac{\Delta' M}{\delta_1}$, etc., whence approximately,

$$\frac{\Delta' M}{\delta_1} = \frac{d\,f(\,)}{d\,M_1},\quad \Delta' M = \frac{d\,f(\,)}{d\,M_1}.\,\delta_1,\quad \Delta'' M = \frac{d\,f(\,)}{d\,M_2}.\,\delta_2, \text{ etc.} \qquad \text{X.}$$

2d. What changes, δ_1, δ_2, etc., in the components M_1, M_2, etc., would, if taken separately, each produce an assigned change $\Delta' M$, $\Delta'' M$, etc., in M? Obviously, this is merely the converse of the 1st case, whence

$$\frac{\Delta' M}{\delta_1} = \frac{d\,f(\,)}{d\,M_1}, \text{ etc.}$$

$$\therefore \delta_1 = \Delta' M \Big/ \frac{d\,f(\,)}{d\,M_1},\ \delta_2 = \Delta''\ M \Big/ \frac{d\,f(\,)}{d\,M_2}, \text{ etc.} \qquad \text{XI.}$$

Combined or collective effects. The principle of least squares shows that for the general case where $M = f(M_1, M_2, \ldots M_n)$, M_1, M_2, etc., being *independent* variables, the combined effect of the separate changes $\Delta' M$, $\Delta'' M$, etc., will be given *best*; *i. e.*, given with greatest probability in the long run, by the expression

$$(\Delta M)^2 = (\Delta' M)^2 + (\Delta'' M)^2 + \ldots + (\Delta'' M_n)^2 \qquad \text{XII.}$$

which accords with the statement made previously in the paragraphs above. Hence, by substituting the above equivalents of $\Delta' M$, $\Delta'' M$, etc., and, for simplicity, writing Δ for ΔM, we have the following formulæ: Those for the special values of $f(M_1, M_2, \ldots M_n)$ are deduced directly from the general case by inserting the values of $f(\ )$, and performing the differentiation. $b =$ a known constant.

$$M = f(M_1, M_2, \ldots M_n)$$

$$\Delta^2 = \left(\frac{d\,f(\,)}{d\,M_1}.\,\delta_1\right)^2 + \left(\frac{d\,f(\,)}{d\,M_2}.\,\delta_2\right)^2 + \ldots + \left(\frac{d\,f(\,)}{d\,M_n}.\delta_n\right)^2 \qquad \text{XIII.}$$

$$M = M_1 \pm M_2 \pm \ldots \pm M_n$$

$$\Delta^2 = \delta_1^2 + \delta_2^2 + \ldots + \delta_n^2 \qquad \text{XIV.}$$

$$M = b_1 M_1 \pm b_2 M_2 \pm \ldots \pm b_n M^n$$

$$\Delta^2 = (b\,\delta_1)^2 + (b_2\delta_2)^2 + \ldots + (b_n\,\delta_n)^2 \qquad \text{XV.}$$

$$M = b\cdot M_1 \ldots M_1 \cdot M_n$$

$$\left(\frac{\Delta}{M}\right)^2 = \left(\frac{\delta_1}{M_1}\right)^2 + \left(\frac{\delta_2}{M_2}\right)^2 + \ldots + \left(\frac{\delta_n}{M_n}\right)^2 \qquad \text{XVI.}$$

$$M = \frac{b_1\,.\,M_1 \ldots}{b_2\,.\,M_2 \ldots}$$

$$\left(\frac{\Delta}{M}\right)^2 = \text{same as preceding.} \qquad \text{XVII.}$$

$$M = b \,.\, M_1^{\pm n} \quad \Delta^2 = \left(\frac{d f M_1}{d M_1} . \delta_1\right)^2 = \left(\pm n b M_1^{\pm n - 1} \delta_1\right)^2$$

$$\therefore \left(\frac{\Delta}{M}\right)^2 = \left(\frac{\pm n \delta_1}{M_1}\right)^2 \quad \therefore \frac{\Delta}{M} = \pm \frac{n \delta_1}{M_1} \qquad \text{XVIII.}$$

$$M = \varphi(M_1) \cdot \rho(M_2) \ldots \sigma(M_n)$$

$$\left(\frac{\Delta}{M}\right)^2 = \left(\frac{d \varphi(M_1)}{d M_1} \cdot \frac{\delta_1}{\varphi(M_1)}\right)^2 + \left(\frac{d \rho(M_2)}{d M_2} \cdot \frac{\delta_2}{\rho(M_2)}\right)^2 + \cdots + \left(\frac{d \sigma(M_n)}{d M_n} \cdot \frac{\delta_n}{\sigma(M_n)}\right)^2 \qquad \text{XIX.}$$

$$\left(\frac{\Delta}{M}\right)^2 = \left(\frac{\delta \varphi(M_1)}{\varphi(M_1)}\right)^2 + \left(\frac{\delta \rho(M_2)}{\rho(M_2)}\right)^2 + \cdots + \left(\frac{\delta \rho(M_n)}{\rho(M_n)}\right)^2 \qquad \text{XX.}$$

Of the special cases, the two most common may readily be put into words. When the f is the sum or difference, the square of the resultant change *in units* = the sum of the squares of the component changes *in units*. When f is a product, or quotient, the square of the resultant *fractional* change = the sum of the squares of the component *fractional* changes. The last special case calls for the following further notice.

Separation into factors. We have often to deal with an expression which is a somewhat complicated function of several independent variables, so that its differentiation is cumbrous, but which may readily be separated into factors, each of which is a function of *but one* independent variable. Factoring thus would give $M = \varphi(M_1) . \rho(M_2) \,.\,.\, \sigma(M_n)$ as in XIX. Then substituting in XIII, and carrying the differentiation as far as we can, *i. e.*, to the indicated differential $\frac{d\varphi(M_1)}{d M_1}$, etc., we deduce the form of XIX. But if for differentials we substitute finite changes, we may write for $\frac{d\varphi(M_1)}{d M_1}$, $\frac{\delta \varphi(M_1)}{\delta M_1}$; etc. Then

$$\left(\frac{\Delta}{M}\right)^2 = \left(\frac{\delta \varphi(M_1)}{\delta M_1} \cdot \frac{\delta_1}{\varphi(M_1)}\right)^2 + \left(\frac{\delta \rho(M_2)}{\delta M_2} \cdot \frac{\delta_2}{\rho(M_2)}\right)^2 + \cdots + \left(\frac{\delta \sigma(M_n)}{\delta M_n} \cdot \frac{\delta_n}{\sigma(M_n)}\right)^2$$

which becomes identical with XX when we cancel δ and δM_1, which are merely two expressions for the same quantity, provided that we remember that $\delta \varphi(M_1)$ etc., are the changes due to δ_1, etc., in the variables M, etc. This process is often a convenience, and illustrations of its use will be given later. In words, expression XX becomes, the square of the resultant fractional change = the sum of the squares of the fractional changes *in the factors*.

Applications. For present purposes these formulæ are to be used in computing the effects upon the final result due to deviations or errors in the component measurements. The values to be used for δ will thus be precision measures or errors, as the case may be. The discussions will be intended to apply especially to cases where the number n of the variables is small, as is usual in physical work. In order to secure for the formulæ the most favorable conditions, the value of n being in general small, no determinate error should be allowed to enter into the precision measures. If the effect of such is under consideration, it must be separately studied by independent differentiation. Such cases often occur in considering the effect of omitting known corrections, or of dropping significant figures from known numerical constants, etc.

It has been shown already that when all determinate sources of error have been as far as possible eliminated, there remain only precision measures to be considered. Hence in the equations for collective effects, we have properly to deal only with precision measures as δ's, and thus the resulting Δ is a precision measure of the same kind as the δ's. In any single equation, of course, all the δ's must be of the same kind; *e. g.*, all must be *ad*'s and *AD*'s, or all *pe*'s and *PE*'s, etc. A $\delta_1 = ad$ may obviously be combined with a $\delta_2 = AD$, if M_1 is a single measurement and M_2 a mean, but an *ad* cannot be combined with a *pe*. The resulting Δ will necessarily be an *ad* if any one or more of the δ's is an *ad*; but if all δ's are AD's, then the Δ may of course be regarded as a AD. This classification of the Δ is, however, unimportant. The point is, that Δ is the *precision* measure of the result M. If any component, *e. g.* M_1, were obtained as a direct uncorrected measurement, then its δ would be simply the average deviation of the measurement. But if this component M_2 is in itself a complex or indirect quantity, as is usual, its δ must include the measures of all sources of deviation, viz., from observations, corrections, component measurements, etc.

The formulæ are applicable to two somewhat distinct cases.

1st. Given values of $\delta_1, \delta_2, \ldots, \delta_n$ to compute their effect, either separately or together, on M.

2d. Prescribed a definite limit of precision or accuracy in the final result; to compute beforehand what grade of *precision* or *accuracy* (to be expressed by δ_1, δ_2, etc.) is necessary in each component in order that the final result shall not be affected beyond the assigned limit.

In the second of these applications it is, of course, essential to know beforehand roughly approximate values of the various quantities, M_1, M_2, etc., but very roughly measured, and even estimated or computed values, are usually sufficient. Thus these applications can generally be made in advance of the construction of apparatus for an investigation, and may serve to show whether a proposed investigation, or instrument, or process, probably can or cannot be made to yield a desired result, or to show what the proportion of parts and the arrangement of apparatus should be. They enable us also to deduce rules for the use of places of significant figures.

Distribution of precision amongst components. In making the second application, it is necessary to determine beforehand upon some relative distribution of precision amongst the components. The simplest would be that which would assign to the δ's such values that *each* should produce an *equal effect* on the final result. But this would not be invariably the best distribution, since it might conceivably demand an amount of labor in making one or more of the measurements which would be widely disproportionate to that involved in making the others. It cannot, however, be much departed from, and should usually be the basis of computation. Yet it is always of advantage to make any δ smaller than this requirement would indicate, if this can be done with little more than an equal share of labor; provided, however, that it be understood that there is but slight advantage in reducing any δ much below one-tenth of its value for equal effects. The general solution for "equal effects" is given below.

Formulæ for equal effects. The formula for the "combination of errors" for the general case $M = f(M_1, M_2 \ldots M_n)$ has been given at p. 47, as M_1, etc., being independent variables,

$$\Delta^2 = \left(\frac{d f()}{d M_1} . \delta_1\right)^2 + \left(\frac{d f()}{d M_2} . \delta_2\right)^2 + \ldots + \left(\frac{d f()}{d M_n} . \delta_n\right)^2 \quad \text{XIII}$$

Now, in order that each δ should have an equal effect on Δ, *i. e.*, that each source of deviation should have an equal effect with each of the others on the final result, the terms of the second member must be all equal. Thence,

$$\frac{d f()}{d M_1} . \delta_1 = \frac{d f()}{d M_2} . \delta_2 = \ldots = \frac{d f()}{d M_n} . \delta_n = \frac{\Delta}{\sqrt{n}} \quad \text{XXI.}$$

Hence,

$$\delta_1 = \frac{\Delta}{\sqrt{n}} \Big/ \frac{d f()}{d M_1}\,; \quad \delta_2 = \frac{\Delta}{\sqrt{n}} \Big/ \frac{d f()}{d M_2}\,; \ldots;$$

$$\delta_n = \frac{\varDelta}{\sqrt{n}} \Big/ \frac{d f()}{d M_n} \qquad \text{XXII.}$$

Ordinarily, the assigned limit for error in M is given as a fraction of M; *i. e.*, as $\frac{\varDelta}{M}$, or as a percentage, which would be $100 \frac{\varDelta}{M}$. Of course the corresponding numerical value of $\varDelta$ may be at once computed by multiplying by M, for $\varDelta = \frac{\varDelta}{M} . M$.

Applying the condition of equal effects to some special cases, we have the following :—

For $M = M_1 \pm M_2 \pm \ldots \pm M_n$,

$$\varDelta^2 = \delta_1^2 + \delta_2^2 + \ldots + \delta_n^2 \qquad \text{XIV.}$$

Hence for equal effects of δ_1, δ_2, etc.,

$$\delta_1^2 = \delta_2^2 = \ldots = \delta_n^2 = \frac{\varDelta^2}{n}$$

$$\therefore \delta_1 = \delta_2 = \ldots = \delta_n = \frac{\varDelta}{\sqrt{n}} \qquad \text{XXIII.}$$

$$\text{For } M = b \cdot M_1 \cdot M_2 \ldots M_n, \left(\frac{\varDelta}{M}\right)^2$$

$$= \left(\frac{\delta_1}{M_1}\right)^2 + \ldots + \left(\frac{\delta_n}{M_n}\right)^2 \qquad \text{XVI.}$$

Hence for equal effects,

$$\frac{\delta_1}{M_1} = \frac{\delta_2}{M_2} = \ldots = \frac{\delta_n}{M_n} = \frac{1}{\sqrt{n}} . \frac{\varDelta}{M} \qquad \text{XXIV.}$$

For $M = \varphi(M) \cdot \rho(M_2) \ldots \sigma(M_n)$,

$$\left(\frac{\varDelta}{M}\right)^2 = \left(\frac{\delta \varphi(M_1)}{\varphi(M_1)}\right)^2 + \left(\frac{\delta \rho(M_2)}{\rho(M_2)}\right)^2 + \ldots + \left(\frac{\sigma(\delta M_n)}{\sigma(M_n)}\right)^2 \qquad \text{XX.}$$

Hence for equal effects,

$$\frac{\delta \varphi(M_1)}{\varphi(M_1)} = \frac{\delta \rho(M_2)}{\rho(M_2)} = \ldots = \frac{\delta \sigma(M_n)}{\sigma(M_n)} = \frac{1}{\sqrt{n}} . \frac{\varDelta}{M} \qquad \text{XXV.}$$

i. e., in this "separation into factors" the *fractional change* in every *factor* is the same, and is equal to $1 / \sqrt{n}$ of the resultant or assigned fractional change in M. In general, however, we wish to find the changes not in the factors, but in the observed variables M_1, $M_2 \ldots M_n$. But having deduced the change in any factor, we may, of course, deduce the corresponding change in the variable contained in that factor by direct differentiation. For the change $\delta\varphi(M_1)$, produced by the change $\delta M_1 (= \delta_1)$, is given by the differential of $\varphi(M_1)$ with respect to M_1. That is,

$$\frac{\delta \varphi(M_1)}{\delta_1} = \frac{d \varphi(M_1)}{d M_1}$$

whence,

$$\delta_1 = \delta \varphi(M_1) \Big/ \frac{d \varphi(M_1)}{d M_1} \qquad \text{XXVI.}$$

similarly,

$$\delta_2 = \delta \rho(M_2) \Big/ \frac{d \rho(M_2)}{d M_2} \text{ ; etc.}$$

The numerical values of $\delta \varphi(M_1)$, etc., for substitution in these are obtained, of course, from the fractional changes in the factors by multiplying these fractions by the numerical values of $\varphi(M_1)$, etc. That is,

$$\delta \varphi(M_1) = \frac{1}{\sqrt{n}} . \frac{\varDelta}{M} . \varphi(M_1),$$

$$\delta \rho(M_2) = \frac{1}{\sqrt{n}} . \frac{\varDelta}{M} . \rho(M_2), \text{ etc.} \qquad \text{XXVII.}$$

Or we may combine these two steps algebraically, and get

$$\delta_1 = \frac{1}{\sqrt{n}} . \frac{\varDelta}{M} . \varphi(M_1) \Big/ \frac{d \varphi(M_1)}{d M_1} \ldots \qquad \text{XXVIII.}$$

$$\delta_2 = \frac{1}{\sqrt{n}} . \frac{\varDelta}{M} . \rho(M_2) \Big/ \frac{d \rho(M_2)}{d M_2} \text{ etc.}$$

And these expressions may be seen, by inspection to be identical with those which would have been obtained had XIX been subjected directly to the condition of equal effects.

In this method of using factors, it must be borne in mind that the results for δ_1, δ_2, etc., are the same as would be obtained by a direct application of the general process only when the factors are wholly independent of each other. Yet in some cases it is convenient to separate into factors which are not wholly independent. Such a process would, however, seldom be used unless the factors were but slightly dependent; for instance, where the variable of one factor entered into another factor merely in a small correction term, or in some other way, in which the resulting values of δ were not sensibly affected by the irregular separation.

Simplification of functions. Since the aim usually is to find, only roughly, approximate values of the δ's corresponding to an assigned $\varDelta$, much labor may be often saved by simplifying, as far as possible, the function $f(M_1, M_2, \ldots, M_n)$ before differentiation. The nature of the simplification would depend on the case in hand, and might consist in omitting small correction terms, the use of approximate formulæ, etc. Also, in the same investigation, it might be possible to use approximate or simplified function in studying some variables, and the complete function in studying others, and different simplifications for various parts of the work.

STATISTICS OF UNITED STATES PATENTS RELATING TO ELECTRICITY, ISSUED IN 1887.

COMPILED BY THOS. D. LOCKWOOD.

In the year 1887, there were issued from the United States Patent Office patents to the number of 20,429. In 1886 there were issued 21,797. In 1885 there were issued 23,330. The year 1887 thus shows a decrease of 1,368 as compared with 1886, and of 2,901 with respect to 1885. Of the patents of 1887, 1248 were issued upon electrical inventions, or upon inventions closely allied to electricity, such as mechanical telephones, a decrease of 89 from last year. The electrical patents of 1887 constitute 6.10% of the whole; as against a percentage of 6.13 last year.

Classified, the electrical inventions patented are as follows:

Telegraphy: Sub-divided into classes:

1. Autographic, Automatic and chemical telegraphs..	6
2. Keys, relays, sounders, repeaters, etc	12
3. Multiple telegraphs	14
4. Printing telegraphs	26
5. Novel systems, etc	18
Total	76
Total in 1886	78

Conductors, insulators and supports are divided as follows:

1. Cables, compound conductors and their manufacture	18
2. Couplings and connectors	30
3. Insulated wires and flexible cords	9

4.	Insulators for pole lines	5
5.	Insulating materials and compounds	10
6.	Line wire, construction, etc	3
7.	Supports, poles, fixtures, cable hangers	16
8.	Underground systems, etc	88
	Total	129
	Total in 1886	125

Patents relating in a greater or less degree to telephony are contained in the following sub-classes :

1.	Battery telephones, or transmitters	31
2.	Magneto and other receiving telephones	19
3.	Telephonic relays and repeaters	0
4.	Telephone central station apparatus	24
5.	Telephone signals	13
6.	Telephone exchange systems and circuit arrangements	15
7.	Induction remedies, etc	5
8.	Individual calls	2
9.	Guards against abnormal currents, and lightning arresters and rods	25
10.	Switch-boards	10
11.	Miscellaneous telephonic utilizations	25
12.	Mechanical telephones	31
	Total	200
	Total in 1886	232

Next come patents relating to the distribution of electricity and its employment in the transmission of power. These are :

1.	Distribution of electricity	38
2.	Railways and motors therefor	20
3.	Transmission of power, telpherage, etc	54
	Total	112
	Total in 1886	132

Patents concerning sources of electricity and its development are as follows :

1.	Batteries—primary	70
2.	" —secondary	20
3.	Dynamos, and magneto machines	40
4.	Dynamo regulators	23
	Total	153
	Total in 1886	173

Electrical illumination has the following showing :

1.	Arc lamps	35
2.	Incandescent lamps	47
3.	Lamp, and electric light fixtures	22
4.	Lighting apparatus, cut-outs and other appliances	21
	Total	125
	Total in 1886	157

Finally, we have a list of well-known applications of electricity which are bunched, because they cannot conveniently be classified otherwise.

1.	Annunciators, indicators, and alarms	62
2.	Burglar alarm and watch clock systems	11
3.	Clocks—synchronizing and time systems	30
4.	Circuit breakers, closers, changers and controllers	24
5.	Electro-magnets, armatures and induction coils	17
6.	Electro-metallurgy	14
7.	Fire and heat alarms, and district telegraphs	59
8.	Measurement, galvanometers, etc	28
9.	Gas lighting	14
10.	Railroad signals and train telegraphs	34
	Total	293
	Total in 1886	314
	Unclassified applications	160
	Unclassified applications, 1886	126

As before stated, the grand total of electrical patents is 1,248.

Alphabetically considered, the inventors' names are classified in the following manner :

Patentees under the initial A = 22 ; B = 125 ; C = 82 ; D = 50 ; E = 59 ; F = 51 ; G = 45 ; H = 100 ; I = 3 ; J = 27 ; K = 32 ; L = 51 ; M = 89 ; N = 14 ; O = 11 ; P = 63 ; Q = 1 ; R = 39 ; S = 151 ; T = 76 ; U = 2 ; V = 19 ; W = 131 ; X = 0 ; Y = 2 ; Z = 3. Total 1,248.

It will be seen that S, has resumed the place of honor, W, B and H coming next. Q does itself proud with one ; while X, is as usual unrepresented.

ELECTRIC ENERGY FROM CARBON WITHOUT HEAT.[1]

BY WILLARD E. CASE.

THE following experiments, undertaken by the author, may be of interest as indicating the way in which the cheap generation of electrical energy may possibly be brought about.

In the first experiment an element was formed through which heat energy was converted into electrical energy, in which the correlation of forces is beautifully illustrated.

It is a sort of voltaic battery, in which plates of tin and platinum forming the electrodes are immersed in a solution of chromic chloride, which has no action on the plates at ordinary temperature, so no current is generated. The cell is hermetically sealed, and when heated the liquid becomes active, and part of one of its elements, chlorine, leaves the chromic chloride, goes over and temporarily combines with the tin, forming a proto-chloride of tin. The chemical action generates an electric current, but soon the tin is all converted into chloride, and the current ceases. When the cell is cooled, this temporary combination of the chlorine and tin is broken up, and the chlorine returns to the chromium proto-chloride. The tin being set at liberty, falls as a metallic precipitate to the bottom of the cell in the form of crystals, ready to renew the combination when the cell is again heated. None of the materials of the element are destroyed; they last an indefinite time. The chlorine changes from chromic chloride to tin and back, as often as the cell is heated and cooled.[2]

It is well known that the voltaic battery converts the potential energy of a metal directly into electricity, without heat. This cell, similar to the voltaic battery, converts heat into electricity. The voltaic battery acts at ordinary temperatures, giving up all the energy stored in the metal, and there is the end of it ; while this cell acts only when heat is applied to it, converting part of this heat into electricity. After the tin has all been converted into chloride the cell becomes inert, no matter how much more heat be applied. The cell must then be cooled to get this tin back into the metallic state, so here it is necessary to have a difference of temperatures, the tin and liquid being simply a medium by which heat is transformed into electric energy.

It will probably be found that the solution of the tin absorbs heat, and so tends to cool the liquid, and the precipitation develops heat, and so tends to warm the liquid, and that the part where the solution occurs must be kept warmer than that where the tin precipitates. An investigation would probably show that when electric currents are generated the heat absorbed by the solution of the tin is in excess of that generated by the precipitation, by the equivalent of the electrical energy developed, and that the possible excess is governed by the second law of thermodynamics. If the cell works between 80° and 180° F., the E. M. F. at the higher temperature is about 0.26 volt, the efficiency is less than 16 per cent., as the possible efficiency $= \frac{T-t}{T}$ reckoned from absolute zero, or $\frac{638^\circ - 538^\circ}{638^\circ} = .157$.

In fact, this cell is a heat engine, analogous to the thermopile, which is said to convert only 2 per cent. of the energy of the coal into electric energy. In practice, probably nothing like 16 per cent. could be utilized.

It is an inexorable law of nature, that under the conditions in which we live a great waste must accompany the transformation of heat into any other form of energy. In the condensing steam engine it requires to condense the steam, four or five pounds of water to every pound of

1. Read before the American Institute of Electrical Engineers, January 10, 1888.

2. This cell has been described in *Proc. Roy. Soc.*, No. 244, 1886.

steam. Three-fourths the heat used goes to warm that water, and is wasted. In hot air engines or gas engines a cold water jacket must be used, and to it goes the larger share of the heat employed. In the thermopile one set of junctions must be kept cool by circulation of air or water. In Edison's pyro-magnetic generator the iron tubes must be cooled by a blast of cold air.

By the second law of thermo-dynamics the minimum amount of heat that goes to this cooling agent is the fraction $\frac{t}{T}$ of the total amount employed, where t is the temperature of the cooler reckoned from the absolute zero and T the higher temperature of the working substance; t can not be less than about 500°, so the numerator of the fraction is always large, and the heat wasted is the larger portion. Understand that this is a law of nature; it is inevitable under the conditions in which we live. No cunningly devised furnace, or feed-water heater, or cut-off, or triple expansion apparatus, or pyro-generator can save this heat. The most that any of these devices can do is to save what would otherwise be wasted over and above the proportion $\frac{t}{T}$. But are we to go on wasting all this energy of fuel? Cannot some means be employed to utilize it? We know that the voltaic battery is not a case of the transformation of heat into electrical energy; it produces electrical energy directly. The second law of thermo-dynamics does not apply, as no heat appears. If we could convert the chemical energy of coal and oxygen into electric energy, directly and cheaply, we would do away with all our steam motors at once. There is no known reason why a cheap substance may not be found which will act on coal and develop electric currents in place of heat. This electric energy would be the equivalent of the heat energy that would be developed by the combustion of the same coal in the ordinary way, and could be transformed into mechanical power, heat, light, etc., with small loss.

So far, little progress has been made in this direction. Some time ago, Jablochkoff produced a battery in which plates of carbon and iron were immersed in fused nitre. The carbon being oxidized, furnished strong currents. The objection to this element is the generation of heat through local action. To it the second law does not apply. Another experiment of more interest than the first is an illustration of an element which is not affected by the second law, as heat is not essential to its operation. The energy due to the complete oxidation of carbon is converted into electric energy directly.

In a glass cell containing sulphuric acid, C. P. Sp. Gr. 1.81, temp. 75 Fah., two electrodes were immersed, one of platinum, the other of lump graphite; only a slight E. M. F. was indicated, 0.007 volt, due to the combination, the graphite acting as a positive element; on the addition of a small quantity of chlorate potassium to the acid, the E. M. F. immediately rose to 00.8 volt, the graphite being disintegrated after a time. This cell polarized rapidly, which was partially prevented by mechanical means. The reaction of chlorate potassium with sulphuric acid may be represented by the following equation: $3\ KClO_3$ (chlorate of potassium) $+\ 2\ H_2SO_4$ (sulphuric acid) $=\ 2\ ClO_2$ (peroxide of chlorine) $+\ KClO_4$ (perchlorate potassium) $+\ 2\ KHSO_4$ (acid sulphate of potassium) $+\ H_2O$ (water).

A method of exclusion was adopted to ascertain the oxidant of this electrolyte; chlorine peroxide (ClO_2) appeared to be the only active agent. It is decomposed by the carbon, chlorine being evolved with some oxygen. It was assumed that in this cell graphitic acid ($C_{11}H_4O_5$) was formed[1] as the result of the chemical actions. There is probably much waste of energy through local action, as the chemical reactions go on when the circuit is open, but to a less extent. In another experiment an electrolyte was formed of sulphuric acid and chlorine peroxide, the gas being formed in a retort by the action of sulphuric acid on chlorate potassium, and conducted over into the acid in which it was dissolved. This cell, with a positive element of graphite, opposed to platinum, gave an E. M. F. of 0.7 volt.[2]

A similar combination was used with a solution of chlorine peroxide in water as the electrolyte. The E. M. F. assigned to these cells is only approximate, as it was found dependent on the quantity of chlorine peroxide in solution, which was constantly changing. The resistance also varied with the different degrees of concentration of the exciting fluid.

Different forms of amorphous carbon were substituted in place of graphite in the first form of cell. Gas carbon gave an E. M. F. 0.007 volt when opposed to platinum in sulphuric acid; on the addition of chlorate potassium the E. M. F. rose to 0.5 volt.

Carbon, produced by the action of sulphuric acid on cane sugar, in this experiment gave an E. M. F. of 0.3 volt.

The carbon of animal charcoal, wood charcoal, coke and anthracite, gave an E. M. F. variable with each form, ranging from 0.3 volt to 1.25 volt. The measurements of E. M. F. of the various combinations were made with the electrode immersed in separate parts of the same solution, that the concentration of the liquid and quantity of gas in solution might be as nearly equal in each cell as possible. It was found when the carbon in comminuted form was contained in a porous cup, that the combination gave an E. M. F. of 1.24 volt, apparently due to the presence of the oxygen of the air.

It is impossible at the present stage of the investigation to assign any definite value of the E. M. F. to these forms of amorphous carbon. In some cases they appear to have an E. M. F. higher than that of graphite.

The energy of the combination of carbon and oxygen when completely oxidized to (CO_2) carbonic acid gas is stated to be 9624 foot-pounds per grain equivalent, which is 2.0594 equivolts.[3] In these carbon elements the E. M. F. is not so high, as there must be deducted the counter E. M. F. or polarization, and the energy due to the force of setting chlorine free.

A resort to chemical analysis, of the products formed by the reaction in the cell, indicates the following conclusions.

First—Carbon produced by the action of sulphuric acid on cane sugar proved to be partially oxidized, or impure carbon.

Analysis gave the following values:

C.	62.20	per cent.
H.	1.61	per cent.
O.	36.19	per cent.

Analysis proves that ($H_2SO_4 \times KClO_3$) sulphuric acid + chlorate of potassium oxidizes carbonaceous bodies, like the above product of (H_2SO_4) sulphuric acid on cane sugar, to CO_2, and further, that such bodies first are changed to compounds soluble in the acid (caramel-like substances), which are rapidly oxidized to CO_2.

Second—Battery carbon of the composition:

C.	96.20	per cent.
H_2O.	.70	per cent.
Iron, SO_3.	2.30	per cent.

The fact was shown that this form of carbon can be oxidized to CO_2.

Third—Wood charcoal, of the following composition after ignition:

C.	94.	per cent.
H_2O.	5.5	per cent.
Silicious res.	.5	per cent.

1. See *Q. Jour. Chemical Soc.*, vol. xii., October, 1859.

2. Great care must be taken in the preparation of this gas, as it explodes at a temperature of about 140 F. It can be preserved in the dark, and is decomposed by sunlight into its component parts.

3. See Sprague's *Electricity*, p. 519.

This, after repeated re-ignition, was oxidized by the electrolyte to CO_2, no intermediate compounds being formed, and further, in case of pure amorphous carbon the oxidation is complete; that is, that all the carbon is oxidized to CO_2.

These analyses were made with the solution at a temperature of 122 F. to hasten the action, the carbon being in contact with the platinum. In these elements the oxidizing material is too expensive for practical use.

Undoubtedly the direction of experiments in the future will be to find some cheap substance which will absorb oxygen from the air and give it up to the carbon; in fact, acting as a carrier of oxygen, so oxidizing it without heat; and this is not improbable, as we already know of subs ances which do this, though giving a low E. M. F.; thus, for instance, the ferric salts are reduced to ferrous by agitating their solutions with carbon, being regenerated by absorbing oxygen from the air.

By pursuing this line of investigation, we can be sure we are not ignorantly striving against any law of nature when attempting to convert the whole potential energy of carbon into electrical energy.

THE DEVELOPMENT OF THE MERCURIAL AIR PUMP.[1]

BY PROFESSOR SILVANUS P. THOMPSON, D. SC., B. A.

WITHIN the range of the physical sciences there are many subjects of interest to the investigator, some of them of importance in the technical industries, which yet are little known, save to the close student of scientific literature. An idea occurs to some original worker, who makes experiments, records results, draws inferences, and embodies his investigations in a memoir or note in the more or less obscure journal of proceedings of some scientific society, where it remains buried amid a heterogeneous mass of like matter. A few years later another worker, not knowing what has been done, stumbles across a similar idea, constructs his apparatus, makes his experiments and observations, and in turn consigns his work to a similar temporary oblivion. Years after, or it may be centuries, the progress of science in other departments reaches a point where it touches the unremembered work of those who are gone. Were that work available, were even a plain clue to its existence known, it would be at once brought into line and made useful. For want of such a clue it remains buried, and the world has to wait for some other to re-investigate what already was a portion of acquired knowledge; and the useful application to industrial purposes is delayed—perhaps for years. He who will explore the dusty corners of science, will hunt up the hidden treasures, arrange them, co-ordinate them with more recent knowledge, and render access to them easy for the busy workers around him, performs a service which, though it brings no renown, is at least useful.[2] In such dusty corners of science lie the scattered fragments of the literature of the mercurial air pump.

All true mercurial air pumps are, of course, based upon the principle of the barometer; that is to say, in all of them the vacuum is constituted in the manner invented by Torricelli, namely, in an enclosed space above a barometric column. In all of them the object is to render the Torricellian vacuum as perfect as possible. In some of them the object is effected by driving the air upwards out of the barometer head by raising the barometric column; in others, the air is forced downwards by the injection of more mercury into the barometer head. In others again, the air is pushed up one barometric column and down another. In some recent kinds of mercurial pump, several of these forms are combined. Other pumps again depend on the injection of mercury at high pressure through an orifice. These distinctions will furnish us with a basis for classification. Before attempting this, however, a few general historical notes may be given.

In 1643, Torricelli discovered the possibility of producing a vacuum above the top of a mercury column, by filling with mercury a tube closed at one end and then inverting it into a cup containing mercury. Until 1650—a period of seven years—when the mechanical air pump was invented by Von Guericke, there was no other way of producing a vacuum, and the Florentine academicians, who made in the interval many experiments on the properties of vacuous space, employed as their pump a Torricellian tube (figure 1) enlarged at its upper part into a bulb or reservoir closed at the summit by a cover, luted on with some suitable sort of cement. The apparatus is figured in Daguin's "Traité de Phisique," vol. 1, p. 278 (edition of 1855). Writing in 1855, Daguin states that though the employment of the vacuum obtained by the lowering of a mercury column had been perfected by Baader and by Hindenburg, their machines required such a large quantity of mercury that they had been abandoned in favor of the mechanical air pump. The Torricellian method of exhaustion was pursued, however, whenever a very perfect vacuum was required, for example, by Count Rumford,[3] in his researches upon the propagation of heat. The bulb to be exhausted he sealed to the top of a barometric tube having a constriction near the top; it was then filled with hot recently boiled mercury and inverted, when the mercury left the bulb vacuous. It was then sealed off before the blow pipe just as exhausted glow lamps are sealed off to-day. An arrangement almost identical with that of the Florentine Academicians was suggested as a novelty so late as 1810, by Traill.[4] In 1845, Edward A. King[5] patented the construction of an incandescent electric lamp, having a carbon pencil situated in the Torricellian vacuum at the upper end of a barometer tube, a further suggestion being made for sealing the exhausted lamp. Amongst still more recent methods of producing in a glow lamp a Torricellian vacuum without the aid of any specific pump, may be noted that of André,[6] who seals the lamp globe to the top of a barometric tube, another short tube opening into the bulb being sealed on above. Mercury is driven from below until it fills the lamp, when the upper tube is temporarily stopped, the mercury being then lowered, creating a vacuum into which the occluded gases are liberated; the mercury is then raised, and these gases

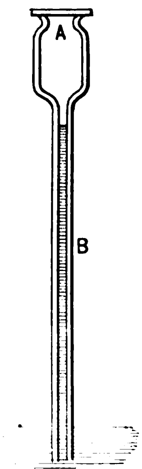


FIG. 1.—Tube Used by Florentine Academicians for Exhausting.

expelled through the stopper, and the lamp is sealed at the top; then the mercury is lowered and the lamp is sealed off at the bottom. Swinburne[7] has also tried this method, but has not found it successful. None of these processes of utilizing the Torricellian vacuum amounts to the invention of a distinct Torricellian air pump. Although most of the mercurial air pumps to be described started from the fundamental notion of producing a barometric vacuum, it seems possible, if not probable, that some, at least, of the various forms had a different origin. Two of the main defects of the ordinary mechanical air pump, are the faulty packing of the pistons and the unavoidable clearance space between the piston and the end of its cylinder. It naturally occurred to several experimenters, possibly to many, that both these defects might be obviated by covering the piston with a layer of mercury. Air pumps thus provided with a mercury packing have been described by Kravogl[8] for exhausting, and by Régnault[9] and Cailletet for compressing. In the following sketch, however, attention is confined to the barometric species of pump. It will be convenient to classify these machines under the following heads:—

CLASSIFICATION OF MERCURIAL AIR PUMPS.

1. Those which drive the air up a barometric tube.
2. Those which drive the air down a barometric tube.

1. Read before the Society of Arts, London (Eng.), Wednesday, Nov. 23, 1887.

2. The author here desires to express his indebtedness to the many friends who have assisted in collecting this information; also to the valuable paper by Herr E. Bessel-Hagen, referred to in the text. He also desires to refer to a memoir by Prof. Hellmann, of Riga, a copy of which he received only after the greater part of this paper was already compiled.

3. Rumford. Essays, vol. ii., p. 393. (Edition 1798.)

4. Traill. "Nicholson's Journal," xxi., pp 63 and 161.

5. King. Specification of Patent, No. 10,919, 1845.

6. André. Specification of Patent, No. 4,654, 1881. Electric Illumination, vol. i., p. 665.

7. See *Electrician*, xix., 159, July, 1887.

8. Kravogl. "Carl's Repertorium," iii., 362, 1868. See also Deschanel's "Natural Philosophy" (1881), i., 190. Similarly a mercury packing was employed in a water pump by Haskins, and is described in Desagulier's Course of Experimental Philosophy (1763), vol. ii., p. 491.

9. Regnault. "Rélation des Expériences," ii., 553.

3. Those which drive the air up one barometric tube and down another.
4. Combination pumps.
5. Injection pumps, dependent in their action upon the velocity of efflux of a stream of mercury.
6. Mechanical mercurial pumps.

Under the first three of these classes there are sub-classes comprising "shortened" pumps.

CLASS 1.—UPWARD DRIVING PUMPS.

The oldest of all mercurial air pumps belongs to the class in which the air is forced upwards above the top of a barometric column. It was invented by Emanuel Swedenborg, the famous theosophist, and is described in his "Miscellanea,"[1] published in 1722. The apparatus and a drawing of the machine is given, which is reproduced in figure 2. A glass receiver, B, stands upon a plate, A, as in the ordinary mechanical air pump, and the plate, A, is supported on three legs forming a tripod table. "Beneath this table," to follow Swedenborg's own words, "there is a certain conical vessel, E, of iron, hollow, and accurately fixed on the under side of the table so that it includes two apertures, *c* and *d*, furnished with valves." The valve *c*, opens downwards, the valve *d*, upwards. The lower end of the iron vessel ends in a flexible leather tube, *f f*, to which is adapted a piece of iron tube, *g g*, ending in an open mouth-piece, *m*. This iron tube was to be alternately raised and lowered precisely as is done in the modern Geissler or Toepler pump with the mercury vessel. Swedenborg's instructions are precise.

"OPERATIO.—Immitte mercurium vivum per (*m*), illa copia, ut repleat (*f*) (*f*) et aliqualem partem E; si dein sursum levas (*g*),

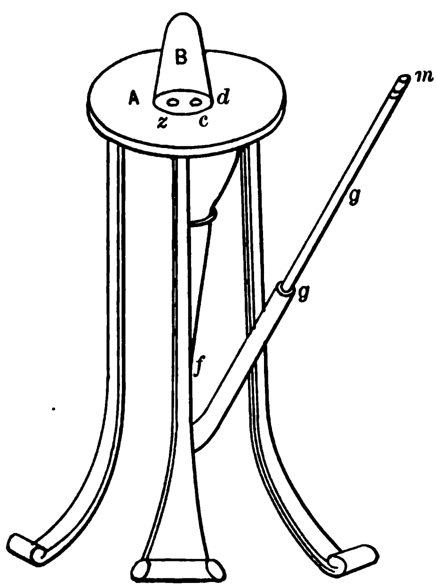


FIG. 2.—Swedenborg's Mercurial Air Pump.[2]

tunc mercurius ascendit in E usque ad mensulam: si dein demittis idem (*g*) infra altitudinem 28 pollicum, tunc descendit mercurius in E, attrahit secum aërem ex recipiente per valvulam (*d*), et sic levando et demittendo, dum omnis aër sit exantlatus. Habeas etiam foramen quoddam in (*z*) sub mensula, quod aperias ope trochleæ, et immittas aërem cum velis."

Further instructions say that the lifting must be continued until some drops of mercury come out at *d*. The nature of the valves, *c* and *d*, is not stated; they appear to have been such as were used in the current form of mechanical air pump.

In the above description and figure, Swedenborg's lettering is adhered to, but it may be convenient to state that in all the following cuts the lettering adopted is as follows:—

A.—The "pump-head" or hollow globe, which is filled and emptied.
B.—The barometric column or tube, also called the "shaft" of the pump.
b.—Barometric gauge.
D.—Drying apparatus.
E.—Eject tube or valve.
F.—"Fall tube."
G.—Gauge.
g.—The flexible lifting tube connecting S and B.
H.—Overhead tube.
J.—Mercury valve.
K.—Collecting chamber.
L.—Pressure chamber at bottom of shaft.
M.—Second chamber for partial vacuum.
N.—"Side tube."
P.—Piston.
p.—Plug of rubber.
R.—"Receiver."
r.—Regulating pinch cock.
S.—"Supply vessel," or reservoir of mercury.
s.—Rubber packing.
T.—Tap.
t.—Air trap.
U.—The valve opening inwards from the exhaust tube to the lower end of the pump head.

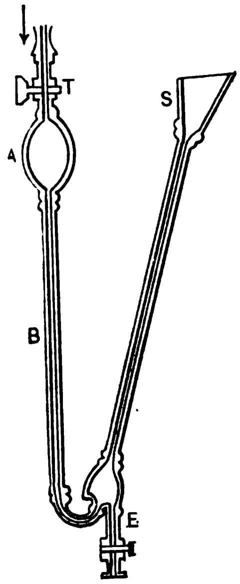


FIG. 3.—Baader's Pump. (First Form.)

V.—The valve opening outwards at the upper end of the pump head.
W.—Winch.
Y.—Three-way communication to atmosphere or auxiliary pump.
Z.—Return tube for mercury.

Sixty years elapsed before a second form of mercurial pump was devised, by Dr. Joseph Baader,[3] who, about 1784, devised the pump depicted in figure 3. This pump consisted of a hollow

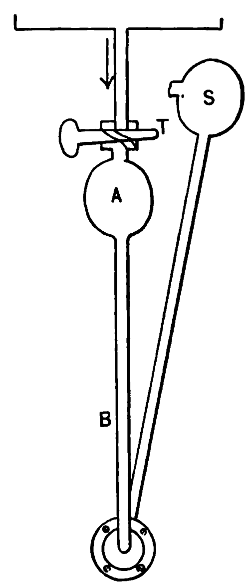


FIG. 4.—Baader's Pump. (Second Form.)

ellipsoidal vessel, A, at the summit of the barometric column, B, terminating above in a passage containing a three-way tap below it, bent round into a chamber with an outlet-tap, and having a second rigid tube, inclined at an angle, ending above in a funnel-shaped vessel to receive the mercury. To work this pump, the

1. Swedenborg. "Miscellanea observata circa res naturales, el praesertim circa mineralia, ignem, et montium strata." Lipsiæ, 1722, p. 101. See also "Gren's Journal," vol. iv., p. 407.

2. Swedenborg. "Miscellanea observata circa res naturales." Lipsiæ, 1722. Figure 11.

3. Baader. See Hübner's "Physikalisches Taschenbuch." Salzburg, 1784, p. 630, referred to in Gehler's "Physikalisches Wörterbuch," vi., p. 602 (ed. 1831).

bottom tap was closed, and the three-way tap was turned so as to make the pump head, A, communicate with the outer air. Mercury was then poured into S until A was filled; the three-way tap was then turned to cut off communication with the air, and to connect A with the receiver or other vessel to be exhausted. The bottom tap was then opened, and a portion of the mercury permitted to run out until the top of the barometric column was below A, producing a partial vacuum in the pump head and the receiver. The lower tap was then closed, the three-way tap returned to its former position, and the mercury which had flowed out of the pump was poured again into S, and the operation repeated. It will be obvious that this operation is equivalent to raising and lowering the supply vessel, as in the pumps of Geissler and Toepler, and their prototype of Swedenborg. Baader had a curious history. In 1784, when this pump was devised, he was studying in Vienna. He afterwards went to Göttingen, thence to Edinburgh, where he took the degree of Doctor of Medicine; but he quitted the medical profession for that of mining, and was afterwards connected with an iron works at Wigan. Gehler states that Baader abandoned his first form of pump in favor of a second,[1] shown in figure 4, which differs from figure 3 in

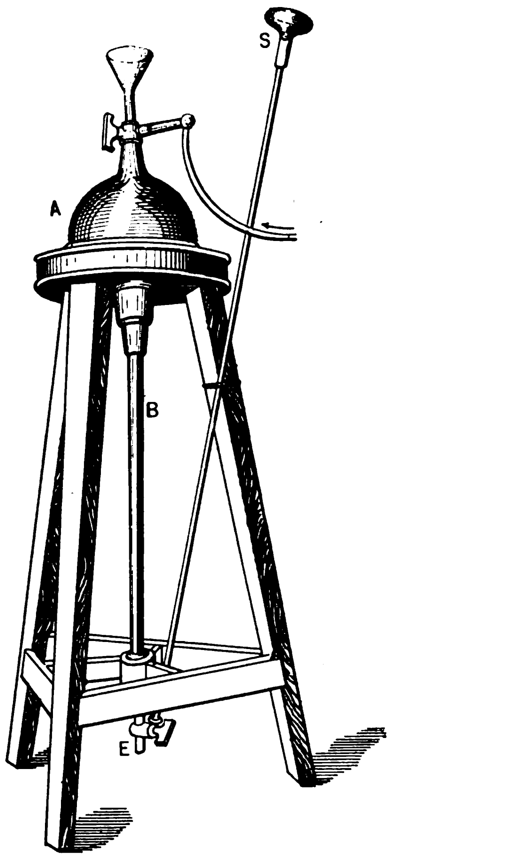


FIG. 5.—Pump in University College.

having the supply vessel capable of being raised and lowered, not by a flexible tube, but by turning it about on a joint provided at the meeting point of the barometric tube and the supply tube.

A very finely constructed pump, on Baader's principle, exists in the collection of apparatus in the physical laboratory of University College, London, having apparently been acquired in April 1828. There is no maker's name or date on the apparatus, but it belongs to, and is catalogued as being "the Torricellian part" of a fine double-barrelled air pump (price £100) by the famous instrument maker, John Cuthbertson, of Amsterdam and London. It is shown in figure 5. The exhaust pipe of brass leads from the three-way tap at the top to a union joint below the plate of the mechanical pump, so that the exhaustion having been carried in the ordinary way to a certain point, it should be completed by using the Torricellian part. The apparatus is mounted on a massive tripod of mahogany; the fittings of the taps are of metal (steel or iron); the height from floor to the top of the exit funnel is just under two meters; the height from the bottom tap to the bottom of the pump head is just over one meter. The barometric tube, B, is of glass, as is also the supply tube. The pump-head is a substantial glass vessel, almost exactly one meter in external circumference, hence it would require about 400 pounds of mercury to work the pump. Professor Carey-Foster states that it is believed to have been acquired by Dr. Lardner's direction; he has no knowledge of its having been used. I have not been able to discover in any of Cuthbertson's pamphlets or price catalogues now extant any reference to this part of the apparatus.

A pump on the same principle was patented in 1881 by Mr. Rankin Kennedy. It is described later.

In 1787, C. F. Hindenburg[2] described the pump shown in figure 6, closely resembling Baader's) but having a piston and cylinder for the purpose of driving the mercury up and down in the barometric tube.

Cazalet,[3] of Bordeaux, states in 1798, that he has constructed

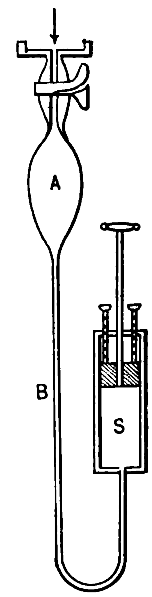


FIG. 6.—Hindenburg's Pump.

an apparatus like Hindenburg's, of glass and iron, and that he has succeeded with it in getting an exhaustion of one millionth of an atmosphere; how he measured this does not appear. A similar kind of pump appears to have been used by Michel.[4]

In 1804, A. N. Edelcrantz[5] published a "Description of a

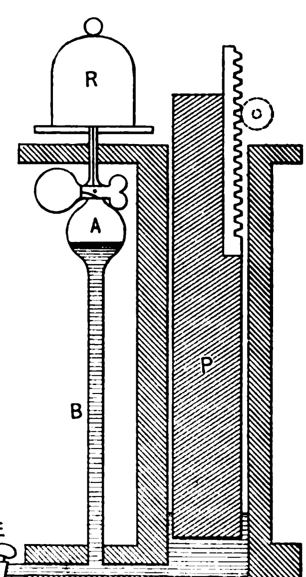


FIG. 7.—Edelcrantz's Pump.

mercurial air pump of unlimited exhausting power, with a wooden piston." This pump (figure 7), which appears to have

1. Baader. See Hübner's "Taschenbuch," cited above; referred to, with figure, in Gren's "Journal der Physik," ii., p. 326; see also Hindenburg. "De Antlia Baaderiana," 4to Leipzig. 1787, referred to in Young's "Lectures on Natural Philosophy." A quarto volume published at Bayreuth, in 1797, under the title "Theorie der Pumpen," is possibly by the same Baader.

2. Hindenburg. See Gehler's "Physikalishes Wörterbuch," vi., p. 603 (1831 edition), which refers to Hindenburg, "Antliæ novæ hydraulico-pneumaticæ mechanismus et descriptio." Leipzig, 4to., 1787. Young mentions also Hindenburg, "De Antlia Baaderiana." Leipzig, 4to., 1787; and to Hindenburg "De Antlia Nova," Leipzig, 4to., 1789.

3. Cazalet. "Gren's Journal," i., p. 478.

4. Michel. See "Gren's Journal," ii., p. 129.

5. Edelcrantz. "Nicholson's Journal." vii., p. 188.

been independently conceived, is on the same lines as Hindenburg's, but with superior mechanical arrangements. The three-way tap, instead of being bored diagonally toward the handle, is bored toward the outer end, as in the modern Geissler pumps, and the wooden piston, P, is moved in its stout wooden casing by a rack and pinion motion.

Some years after this "Nicholson's Journal" contains a description of Traill's[1] apparatus, which has already been mentioned. It drew a further communication from R. Bancks, instrument maker in the Strand, that he had constructed similar apparatus for Mr. Children at a prior date.

In 1824, Joseph H. Patten[2] wrote an "Account of a New Air-pump," which, like those of Hindenburg and Edelcrantz, had a piston to raise and lower the mercury, but which in another point more nearly resembled the original pump of Swedenborg. The pump-head consisted of a wide-mouthed glass globe, on the top of which was fixed a flat metal plate with a raised rim. In the centre of this was adapted a metal pipe, having a valve opening downwards below it. This valve, a mere metal plug, was held upon a stiff wire which entered the tube above, and was continued downward to the summit of the barometric tube, where it ended in a ball float. When the mercury rose it lifted the ball and closed the valve, and maintained it closed till it once more fell. The air in the pump-head was expelled through a separate valve, opening outward in another part of the plate. Patten suggested that instead of the stiff wire, ball, and valve, the exhaust tube should be prolonged downwards to near the bottom of the globe. The publication of this description drew from Professor J. F. Dana[3] some remarks suggesting, appar-

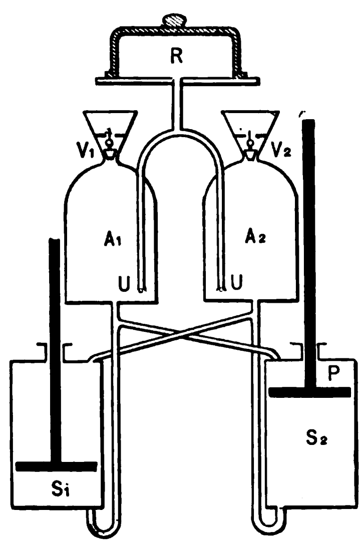


FIG. 8.—Kemp's Double-Acting Pump.

ently without knowledge of prior inventors, that it would be preferable to use a three-way tap. To this Patten replied in a later issue in a strongly personal vein.

A more complex form of pump, in which the mercury was moved by air pressure, applied by pouring mercury into a second vessel containing air—somewhat on the plan of Hero's fountain—was described in 1824 by Dr. E. Romershausen,[4] and in 1825 by Uthe.[5] In each case a complicated six-way tap was requisite.

In the same year a pump by Oechsle[6] was described, having a three-way tap connecting the pump-head alternately with the air and with the receiver to be exhausted, and provided also with a barometer gauge beneath the receiver. The mercury was lowered and raised, as in Edelcrantz's pump, by a large wooden piston, but worked by a chain and winch.

Next in strict historical order is the very remarkable pump of Mile, 1828, which, however, belongs to the third class of machines.

K. T. Kemp,[7] of Edinburgh, in 1830, designed a remarkable double-acting pump. In this machine a winch, manipulated like that of the ordinary mechanical air-pump, moves two pistons up and down in two cylinders, figure 8. These are full of mercury, which is thereby driven alternately into the two exhausting chambers, and which serve as pump-heads. They are provided with valves to admit air from the receiver, and also with valves opening outwardly to let out the expelled air. The latter pair of valves are ingeniously provided with floats, so that they close while there is still some mercury remaining above the actual valve to seal the joint and make it air-tight. The double pump of Gardiner, hereinafter described, closely resembles that of Kemp.

The year 1855 brings us to the famous pump of the late Dr.

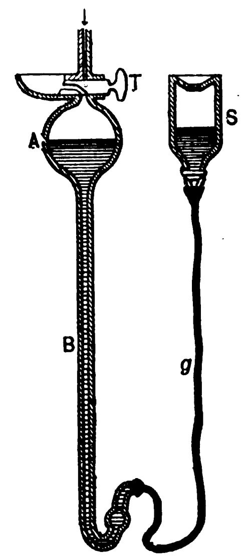


FIG. 9.—Geissler's Pump. (First Form.)

H. Geissler, of Bonn, which in his hands did such excellent work for exhausting the Geissler vacuum-tubes The first public mention of this pump appears to be in a pamphlet entitled, "Ueber das geschichtete elektrische Licht," published in Berlin, in 1858, by Dr. W. H. Theo. Meyer. As depicted in that pamphlet, the apparatus strikingly resembles the second form of Baader's pump. The form given by Geissler to this apparatus is shown in figure 9; which shows the vessel containing the supply of mercury, S, con-

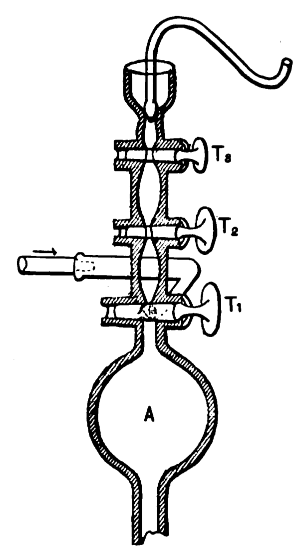


FIG. 10.—Geissler's Pump. (Recent Form.)

nected to the lower end of the barometric column, B, by a flexible India-rubber tube, g. The pump-head, A, is provided at the top with a large three-way tap, T. The operation of this simple contrivance is obvious; the air in the pump-head is repelled by raising the supply vessel, whilst the tap is in such a position that the pump-head communicates with the outer air. The tap is then turned so that the communication with the outer air is cut off, and communication is established with the vessel to be exhausted. This being done, the supply vessel is lowered down, when the

1. Traill. "Nicholson's Journal," xxii., pp. 63 and 161.

2. Patten. "Silliman's Journal," viii., p. 144, 1824, and ix., p. 92, 1825. An almost identical apparatus, called "oil air-pump," by Sadlier, is described by Gehler, vi., p. 606.

3. Dana. "Silliman's Journal," viii., p. 275.

4. Romershausen. "Neue hydrostatische Luft-pumpe." "Kastner's Archiv für Naturlehre," ii., p. 359, 1824.

5. Uthe. "Dingler's Polytechnisches Journal," xvii., p. 272, July, 1825.

6. Oechsle; see Wucherer: Beschreibung einer grossen Quecksilbernen Luftpumpe, welche sich in dem physikalischem Cabinet in Karlsruhe befindet. "Kastner's Archiv," v., p. 329, 1825.

7. Kemp. Description of a new Torricellian Air-Pump. "Edinburgh Journal of Natural and Geographical Science," ii., p. 95, 1830. See also in Fechner's "Repertorium des Experimental-physik," i., p. 116; and Taf. 2, figure 13, 14, 1832. Also "Baumg und Ett. Zeitschr., viii., 193.

mercury in the pump-head sinks, and draws in air through the exhaust tube. The tap is then turned again, and the supply vessel is again raised to expel the air that has been drawn in, then the tap is turned and the supply vessel again lowered. By repeating these operations a sufficient number of times, the air remaining in the apparatus is reduced to a very small portion of its original amount, and the column of mercury in the tube, B, stands up to very nearly the height of the barometer. The perfection of the vacuum is limited by two causes: the inherent imperfection in the three-way tap, and the impossibility of expelling the film of air which adheres to the inner surface of the pump-head. However perfectly the tap may be ground into its seat, however carefully it is lubricated with stiff grease, still, air-films will remain between the working surfaces. There is a tendency for a channel to be formed in the film of grease at that part of the conical periphery of the tap where the apertures into it slide round against the internal wall of the glass seat; and through this channel in the glass, minute bubbles of air force their way. Moreover, the grease itself may give off vapors which spoil the perfection of the vacuum. The Geissler pump is, moreover, subject to other defects, amongst which may be enumerated the heavy labor of raising and lowering the supply vessel, the liability to accident to the glass top, the liability to fracture of the pump-head. The latter accident occurs not unfrequently, if, after a certain degree of exhaustion has been attained, the supply vessel is suddenly raised, for then, there being little or no air in the pump-head to serve as a cushion, the mercury rising in the pump-head strikes with a sudden blow against the upper portion of the pump-head and fractures it. The long barometric tube or shaft of the pump is also liable to fracture. The working of the

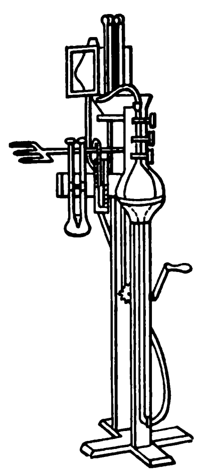


FIG. 11.—Geissler's Pump, (Complete.)

tap, being done by hand, requires continuous attention; lastly, the process of exhaustion is slow.

The subsequent improvements relate to the removal of one or other of these drawbacks. Some of them were introduced by Dr. Geissler himself, and by his successor, Herr F. Müller, of Bonn. The form depicted in figure 9 (taken from Toepler's paper in "Dingler's Polytechnisches Journal," clxiii., p. 426, 1862) shows the kind of three-way tap (a modification of Senguerd's) originally used, in which the passage for the expulsion of the air was carried through the conical body of the top to its end. In another form, the same kind of tap was used, but the exhaustion was made through this longitudinal passage, the external tubular seat being prolonged and connected with the vessel to be exhausted. In this case the air was expelled upwards through the transverse passage through the tap. In yet a third form the exhaust tube was sealed on at right angles to the external barrel, and the tap was pierced (on Babinet's plan) with a three-way transverse passage. In the most recent form given to the Geissler pump by its makers, there are three taps, one of them, a large one, being a three-way tap of the last mentioned kind, simplified by having only one transverse bore of conical form. The arrangements of this pump are shown in figure 10, in which T_1 is the three-way tap, and T_2 and T_3 plain taps of a smaller size. The use of the two upper taps is to enable the last traces of air to be more perfectly expelled from the pump-head. During the ordinary working of the pump the two top taps are always left open. After the exhaustion has reached a sufficient point, the large tap is turned so as to cut off communication with the exhaust tube, and to open communication from the pump-head upwards through all the taps. The supply vessel is then raised so high as to drive the mercury up above the level of the topmost tap. The top tap is then closed, and, by sinking the supply vessel, the mercury is caused to fall below the pump-head. It is then slowly raised, driving before it all the air that may remain in the pump-head, and collecting it just below the top tap. As soon as the mercury has risen through the second tap, this is then closed, and the mercury once more lowered. It will be seen that if the space between T_2 and T_3 is sufficiently great, this residual air will not become compressed to anything like atmospheric pressure, and hence the air-films forming in the upper part of the pump-head or in the channels of the three-way tap will be comparatively slight. The curved tube at the top is used for collecting the gases extracted in chemical operations; the horizontal exhaust tube is usually connected with drying vessels, and with

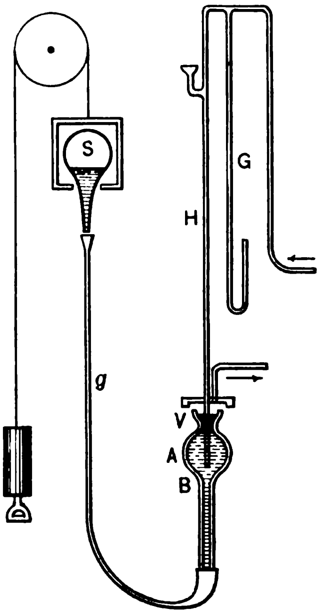


FIG. 12.—Joule's Pump.

appropriate gauges. The complete pump as used for the purposes of the chemical laboratory is shown in figure 11.

Morren's pump[1] is practically identical with Geissler's, save in a detail concerning the three-way tap, which has, instead of having a glass cone with a longitudinal passage pierced through it, a steel cone, with a channel or groove cut in the side. Another almost identical form was described by G. Jolly,[2] about the same

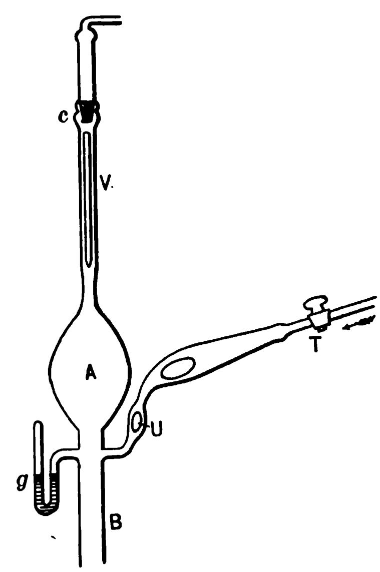


FIG. 13.—Mitscherlich's Pump.

time. It resembled Geissler's first form, but was provided with the mechanical device of a winch and pulley, to raise and lower the supply vessel. This device was speedily adopted by other makers; it may be seen in the latest form of Geissler's pumps. Jolly's pump also has a steel three-way tap. Von Babo[3] sought

1. Morren. "Annales de Chim. et de Phys." March, 1865. See also "Carl's Repertorium der Physik," vol. i., p. 142, 1866. It is depicted in "Ganot's "Physics" (1879), p. 158.

2. Jolly. Ueber eine neue Einrichtung der Quecksilber-Luft-Pumpe. "Carl Repert," i., p. 144. 1866. See also Müller-Pouillet's "Physik" (ed. 1876), vol. i., p. 231; and Mousson's "Physik" (ed. 1879), i.,1878.

3. Von Babo. See Müller-Pouillet," i., 238.

to replace the egg-shaped pump-head by a glass cylinder, strongly held together between circular steel ends, and having two automatic valves opening into and out of it, precisely as in Kemp's pump of 1830 (figure 8). Poggendorff[1] further improved the mechanical lift by adding a counterpoise weight. Alvergniat[2] introduced an automatic valve into the exhaust tube, to prevent the mercury from being driven back into the exhausted vessel. Weinhold[3] modified the glass three-way tap, and added above it a small chamber, above which the opening into the outer air was closed by a second glass tap of similar construction. The use of this upper chamber to secure a more perfect vacuum brings this form almost into identity with Geissler's later form.

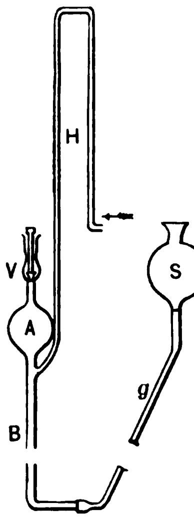


FIG. 14.—Lane-Fox's Pump.

The device of interposing such a chamber between the three-way tap and the external air was independently suggested in 1875 by Kundt and Warburg[4] and appears to have been already adopted by Geissler[5] in 1873.

In the years 1873 and 1874, Dr. Joule[6] devised several forms of mercurial pump, having but one valve, an India-rubber plug, V, fitting into a cone seat at the top of the pump-head, allowing the air to be expelled. A little mercury above it kept the joint secure. The necessity of emptying a second valve was obviated by the device (previously used by Mile) of connecting the vessel to be exhausted to the pump by means of an overhead tube, H, of more than barometric height which passed into the pump-head its open lower end descending nearly to the bottom of the chamber. This acted automatically as a trap; for, on the raising of the supply-vessel, the mercury rising in the pump-head first closed the orifice of the head-tube, so cutting off communication with the air that remained in the pump-head, but never rising in that tube to a height greater than 76 centimeters above the level of the valve. Another feature of Joule's pump was that the supply-vessel was closed at the top, being made of a globular flask. By allowing only a certain amount of air to enter this flask, the pressure inside was kept at less than atmospheric, enabling the length of the shaft, B, to be reduced. Later, a conical ground-glass tube was used in place of the India-rubber plug for a valve.

In 1873, Mitscherlich[7] altered the pump in the manner shown in figure 13. The double function performed by the three-way tap was in this form shared between an automatic valve, V, opening upwards only, and a plain glass tap, T, worked by hand. The valve consisted of a rod of glass, ground conical at its lower end, fitting into a tube of one centimeter internal diameter. This rod was raised from its seat by the mercury as it rose through the pump-head. A perforated cork placed in the eject tube above the valve prevented it from rising too high, otherwise it would, in falling, become jammed. The exhaust tube communicated with the pump through the tap, T, at a point below the pump-head; the communicating tube being enlarged to receive an hydrous phosphoric acid or other drying materials, the same being protected from the rising of the mercury by the interposition of a loosely-fitting glass valve of ovate shape, U.

1. Poggendorff. "Pogg. Ann.," cxxv., 151.

2. Alvergniat. See Pellat, "Cours de Physique" (1883), i., 319.

3. Weinhold's. "Physikalische Demonstrationen" (1883) p. 175. See also "Carl's Repert," ix., p. 78, 1874.

4. Kundt and Warburg. "Pogg. Ann.," 526, 1875.

5. See Bessel-Hagen. "Wied. Ann., xii., 436, 1881.

6. Joule. "Proc. Lit. Phil. Soc., Manchester," xii., 57, 1873; *ib.* xiii., 58, 1874; *ib.* xiv., 12, 1875; see also "Scientific Papers," i, 623; also "Catalogue of Loan Collection of Scientific Apparatus," 1876, p. 133.

7. Mitscherlich. "Pogg. Ann.," cl., 420, 1873.

Another modification, due to Lane-Fox,[8] is shown in figure 14. The valve at the top of the pump-head is a conical glass stopper ground to fit tightly into its seat, requiring to be removed and replaced by hand. The overhead tube, H, which acts as a barometric trap, is joined to the shaft of the pump just below the pump-head. Lane-Fox also suggested the use of an automatic valve (like that of Alvergniat) to obviate the necessity of using the tall head-tube. This pump was for a long time used by the Anglo-American Brush Electric Light Corporation for exhausting the Lane-Fox incandescence lamps; they introduced a number of modifications in detail, one of which consisted in replacing the stopper, V, by an automatic valve resembling Mitscherlich's. A side-tube leads from below the lower automatic valve, U, to the tap of the pump-head. There is also a spark gauge. A drawing of one of the intermediate forms of Lane-Fox pump is given in Gordon's *Electric Lighting* (1884), p. 83.

About the same date, minor improvements were suggested by several persons. Mr. Dew-Smith, of Cambridge, suggested the use, at the top of the pump-head, of an automatic valve consisting of a strip of rubber or silk stretched over an orifice, precisely as in many mechanical air pumps, the valve itself being surrounded by an upper mercury cup to ensure a tight joint. Messrs. Goebel and Kulenkamp,[9] who used an automatic glass valve to close the top of the pump-head, adopted above it a flexible tube, by means of which to return to the supply-vessel the small quantities of mercury which from time to time were driven up through the pump-head, with the ejected air. Guglielmo,[10] applying a very similar device, achieved the not unimportant result of causing the tap at the top of the pump-head to discharge the rejected residual air into a space already partially exhausted. This he accomplished by interposing in the flexible tube connecting the summit of the pump-head with the closed top of the supply vessel a vertical glass tube, about twenty centimeters long, with a three-way tap opening also into the air. Through this tap atmospheric pressure could be momentarily established when the supply-vessel was in its lower position, and nearly full of mercury. When it was raised, the mercury ran out of it into the pump-head, leaving the space in it partially exhausted; and into this vacuous space the three-way tap at the top of the pump-head opened to let out the ejected air. As will be seen later on, this device makes this pump resemble somewhat some pumps of the third group.

Mr. Albert Geissler[11] has replaced the three-way tap by two

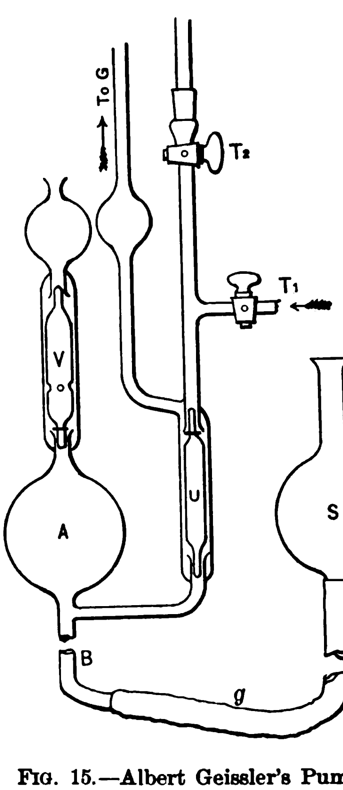


FIG. 15.—Albert Geissler's Pump.

automatic valves (figure 15, p. 30), one of which, V, opens from the top of the pump-head into the outer air; the other, U, admits air from the vessel to be exhausted into the pump just below the pump-head, as in the Mitscherlich and Lane-Fox pumps. These

8. Lane-Fox. Patent Specification 3,494, of 1880.

9. "Wied. Beiblätter," vi., 849. 1882. See also Specification of Patent 5,548, of 1881.

10. Guglielmo. "Wied. Beibl," viii., 789, 1884.

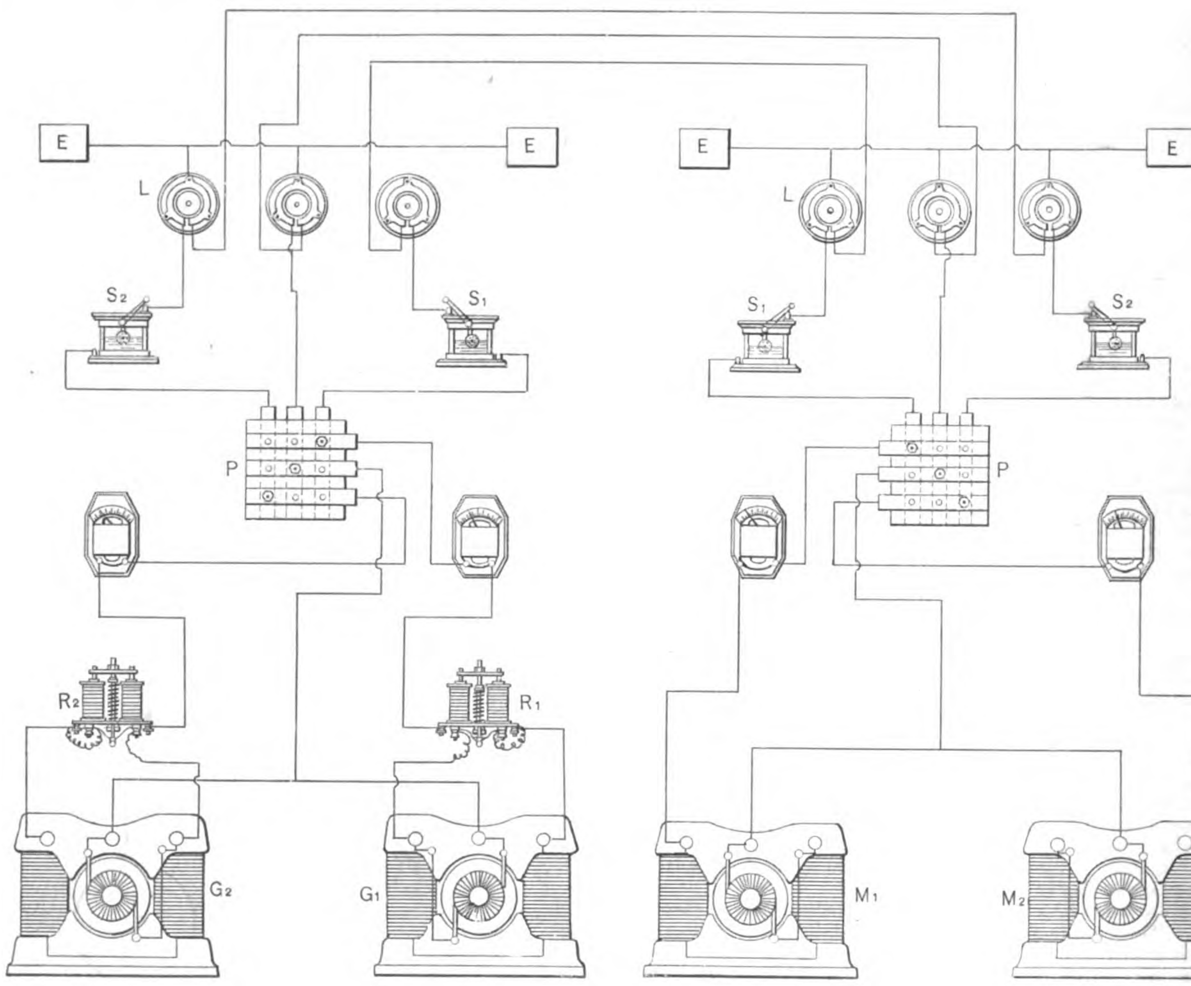
11. A. Geissler. "Centralzeitung für Optik and Mechanik," vii., 12. 1886; also D. R. Patent, No. 32,224, 1885.

valves are hollow tubes of glass, with spindle ends to guide their motion, which float in the mercury when it reaches them. They are provided with accurately ground glass collars instead of conical ends, to fit against the ends of the tubes which they respectively close. An additional tap, T, is interposed for safety between the pump and the vessel to be exhausted. Other tubes lead to the manometric gauge and to the drying apparatus. This form of pump is intended for industrial use, where power is available to keep the supply-vessel slowly rising and sinking. A small improvement of recent date, due to Messrs. Greiner and Friedrichs,[1] consists of a new three-way tap of peculiar construction, pierced with two transverse channels at 45°. Of the three openings, two are at one side of the barrel, one at the other, so that the top has to be worked through 180° instead of 90°, and the channels in the grease do not lead directly from one aperture to another. Hence there is a lesser risk of leakage.

(To be continued.)

ELECTRIC TRANSMISSION OF ENERGY.

In our issue of the 8th of April, 1887, we gave an account of experiments carried out at the Oerlikon Engineering Works with a plant of two dynamos and two motors intended for the transmission of energy from Kriegstetten to Solothurn. These experiments were made by a committee of engineers and scientific men, with a view to ascertain the total commercial efficiency of the transmission plant; but as the machines were in this case placed side by side, the results could only be taken as approximately correct. It is evident that, in such an arrangement of machines and resistances erected within the limits of a covered workshop, the insulation of the circuits presents no difficulty whatever, whereas in the actual installation, when many miles of overhead wires must be used, the insulation becomes a matter of some difficulty, and atmospheric influences may also have some effect upon the performance of the plant. These considerations induced the makers to arrange for some further trials with the plant as actually installed. A committee was appointed, under the presidency of Professor Amsler, of Schaffhausen, the well-known inventor of the planimeter, and the following gentlemen were members: Professor Weber, of the Zürich Polytechnic School, and his two assistants; Professor Hagenbach Bischoff, of Basle; Professor Veith, who occupies the chair of machine construction at the Zürich Polytechnic School; Herr Keller, engineer to Messrs. Escherwyss, of Zürich; Herr Lang, a manufacturer of Derendigen, and Herr E. Bürgin, of Basle, the inventor of the Bürgin dynamo. This committee have just issued their official report on the trials made on the 11th and 12th of October last with the plant as actually installed. Before quoting the results of these trials, it will be well to briefly refer to the general arrangement of this installation. At Kriegstetten there is a water power available, representing about 40 actual horse-power, and the problem was to carry as much of this power as possible to a mill in Solothurn, the distance being four and three-fourths miles as the crow flies; but, allowing for deviations, the length of each circuit may be taken as about five miles. There are at Kriegstetten two generating dynamos, and at Solothurn two motors, coupled up on the three-wire system, as shown in the above illustration. A perspective view of the dynamo was given on page 358, vol. ii. Each dynamo weighs 3 tons 12 cwt., and has a Gramme armature 20 inches in diameter and 14 inches long, the normal speed being 700 revolutions per minute. Referring to the diagram of connections, G^1 and G^2 are the generators at Kriegstetten, and M^1 and M^2 are the motors at Solothurn. R^1 and R^2 are electro-magnetic switches which automatically come into action and short circuit the exciting coils in case of the current rising beyond a certain limit. This provision was introduced in order to guard against the destruction of the generator in case a short circuit should take place somewhere in the line. The current from each of the generators passes through an ammeter and then to a plug board, to which is also connected the balancing wire joining the negative brush of G^2 with the positive brush of G^1. The balancing wire is then carried direct to the middle one of the three lightning arresters, L, and then to the middle wire of the line, whilst each of the outside wires is led through a liquid switch, S^1 S^2, then to a lightning arrester, and to the line. Each lightning arrester consists of a circular metal disc, the edge of which is provided with projecting teeth, and situated in a concentric metal ring, the internal circumference of which is also provided with teeth, but not touching the teeth of the disc. All the discs are connected with a common earth wire and two earth plates, E E. Should a flash of lightning strike the line, the current



KRIEGSTETTEN. SOLOTHURN.

1. Greiner and Friedrichs. See "La Lumière Electrique," xxiii., 335, 1887.

will leap across the intervening space between the teeth of the ring and those of the disc, and will thus be led to earth without passing through the machinery. The same provision against lightning is made at the motor station. The switches s^1 s^2 are of peculiar construction, and consist of a vessel containing a conducting liquid and a perforated metal ball dipping into it. When the current is to be switched off, the handle is turned so as to raise the ball out of the liquid; but the circuit is not immediately interrupted since the liquid within the balls issues in fine streams out of the perforations, and so maintains the connection for a short time after switching off. As the liquid in the ball gets exhausted, and the streams become thinner, the resistance of the liquid connection is gradually increased to infinity, and thus causes the current to gradually diminish to zero. The line wires are supported on Johnson & Philips' patent fluid insulators, and the average span is about 130 feet. Two sets of experiments were made. On the 11th October only one generator and one motor were tested, whilst on the 12th October both generators and both motors were tested. In the latter test the balancing wire was cut out of circuit as of no importance when, as in these experiments, it was quite easy to regulate the load of each motor so as to fairly divide the work between them.

Electrical measuring instruments were fitted up at both stations in rooms sufficiently distant from the machinery, so as not to be influenced by stray magnetism. The current was measured by large tangent galvanometers, and Thomson mirror galvanometers, standard cells, and potentiometers were used to measure the pressure. The object in measuring the current at both ends of the line was to ascertain whether any appreciable leak took place. In addition to these purely electrical measurements, observations were made at the generator station regarding the water level in the head and tail race of the turbine, the position of the regulator on the latter, and the speed of the dynamos and turbine. After the transmission trial on the 11th October was completed, the armature of the dynamo was taken out and replaced by a plain spindle provided at the end with a brake. The turbine was then started again under exactly the same conditions as were noted at the previous trial, and the power absorbed by the brake was measured. The comparison between the power thus measured and the electrical energy given out by the generator is evidently the commercial efficiency of the latter. On the following day both generators and both motors were tested in the same condition as prevails in actual practice, with the only exception that, as already mentioned, the balancing wire was cut out of circuit. This alteration, which could obviously not increase the efficiency of the whole system, was made to simplify the measurements. The power absorbed by the generators was computed on the basis of the previous day's trial from the observed conditions under which the turbine worked, whilst the power developed by the motors was on both days directly ascertained by means of a friction brake fitted to a first motion shaft common to both motors. A small correction was made for the power absorbed by this shaft when running idle. The following tables give the results as published by the committee:—

I.—Electrical Measurements.

Time of trial.	Electromotive force.		Terminal pressure.		Current measured at	
	Generators.	Motors.	Generators.	Motors.	Generators.	Motors.
11th Oct.	1231.6	988.6	1177.7	1041.2	14.20	14.17
" "	1237.0	1016.8	1186.8	1066.1	13.24	13.28
12th Oct.	1836.5	1575.4	1753.3	1656.1	11.48	11.42
" "	2129.0	1896.2	2058.0	1965.2	9.78	9.79

II.—Resistances and Loss of Pressure.

Time of trial.	Resistance of machines.		Line resistance.	Pressure lost in line		Temperature of air. Centigrade.
	Generators.	Motors.		Calculated.	Measured	
11th Oct.	8.741	8.716	9.228	130.9	136.5	+7.5
" "	8.741	8.710	9.228	122.3	120.7	+7.5
12th Oct.	7.251	7.060	9.044	108.7	97.2	+3.2
" "	7.240	7.042	9.040	88.4	92.8	+3.2

III.—Determination of Energy.

Time of trial.	Internal electrical horse-power.		Terminal electrical horse-power.		Actual horse-power.	
	Generators.	Motors.	Generators.	Motors.	Supplied to generators.	Obtained from motors.
11th Oct.	23.76	19.03	22.72	20.02	26.15	17.85
" "	22.27	18.34	21.35	19.23	24.54	16.74
12th Oct.	28.64	24.46	27.34	25.71	30.87	23.21
" "	28.29	25.21	27.37	26.13	30.87	23.05

IV.—Percentage of Efficiencies.

Time of trial.	Electrical efficiency.		Commercial efficiency.		Total efficiency of transmission.	Remarks.
	Generators.	Motors.	Generators.	Motors.		
11th Oct.	90.8	93.7	86.8	89.1	68.3	One generator and one motor.
" "	90.6	91.3	86.9	87.1	68.2	
12th Oct.	92.8	94.8	88.5	90.3	75.2	Both generators and both motors.
" "	91.6	91.4	88.7	88.2	74.6	

An inspection of these figures will show that there is practically no loss of current by leakage on the line. In some cases the current measured at the motor station is slightly below that measured at the generator station; but the discrepancy is exceedingly small, and evidently due to personal or instrument errors, since in some other cases the current received by the motors appears to be even slightly larger than that sent out by the generators, which is obviously impossible. The second table also shows the influence of the air temperature upon the total resistance. The third table gives the power, and the fourth the efficiencies in percentages. It will be noticed that when one generator and one motor only were used, the commercial efficiency was slightly over 68 per cent.; but when both generators and both motors were used, this efficiency rose to about 75 per cent., which is clearly due to the higher voltage employed. On the whole, the result of these trials must be considered highly satisfactory, and Mr. C. E. L. Brown can be congratulated upon having succeeded in transmitting power over a distance of five miles with a loss not exceeding 25 per cent. It is needless to say that so high an efficiency could not possibly have been attained with any purely mechanical system of transmission.—*Industries.*

A NEW FORM OF SECONDARY BATTERY.[1]

BY KILLINGWORTH HEDGES.

(Mem. Inst. Civil Engineers.)

Secondary batteries or accumulators may be said to have become a necessity in private installations of the electric light, and to be as far advanced as any other part of the lighting system. The batteries which are best known are widely different from those designed by the original inventor, M. Gustave Planté, very little attention having been paid to this type until the matter was taken in hand by a French engineer, M. Phillimond Bailly, whose invention I shall have the honor of describing to you to-day. The battery, which has been termed the Phœnix, is of two kinds, Pb-Pb or lead-lead, and Pb Zn or lead-zinc, and it is to the latter to which I will confine my remarks. The idea of using zinc for the cathode or positive plate of a secondary battery is not new in principle, having been described by several inventors, but its adoption for commercial work was not practicable until about a year ago, when M. Bailly introduced this battery in several installations abroad, where they are still employed. M. Reynier had previously designed a battery with a lead or copper plate coated with zinc, but it failed, and long before this Mr. Swinburne tried a similar plan, employing oxide of carbonate of zinc; but both these arrangements were far more expensive than that of M. Bailly, who prepares his zincs by moulding zinc filings with mercury, and compressing it into a rod or plate.

In a lead-zinc battery the action is as follows:—The zinc plate is attacked by the sulphuric acid in the presence of the peroxide of lead, the latter acting as a perfect depolarizer; consequently the reaction is much more energetic than in a lead-lead battery, and the available E. M. F. is, in fact, 2.5 volts, falling to 2.33 when current is taken out. A lead-zinc accumulator is, in fact, a perfect primary battery, in addition to having a large storage capacity, which M. Bailly has found to be five times as much as a lead-lead battery with plates of similar surface. In discharging the zinc plate dissolves in the dilute acid, forming sulphate of zinc, which is decomposed on re-charging, pure metallic zinc being deposited on the zinc plate. The zinc, if properly amalgamated, is thus never consumed, but only dissolved and re-deposited. I have on the table some zinc plates which have been used in a small portable battery which I have used nearly every evening for the past four months, and they are still quite fit for work, although they are simple strips of commercial zinc, and not made on M. Bailly's plan of moulded filings. If the latter is employed I do not see why the zinc plate should not last as long as the peroxide plate. The lead plates of the Planté cell were simple sheets of rolled up lead, and had very little capacity. In the Phœnix battery they are formed of a quantity of fine shreds termed "lead wool" which are interwoven among a number of

1. Paper read before the British Association Meeting at Manchester (Eng.), September, 1887.

strips or fringes cut out of a lead plate, so as to form a sort of basket work, which is submitted to pressure, and then placed in the space left between a porous pot and the outside receptacle. The object has been to have a solid metallic conductor permeating the whole mass of the lead wool, so as to pick up the current with a minimum loss due to internal resistance, which has been the cause of failure of those Planté batteries in which lead wool or spongy lead was employed. M. Bailly compares his mode of picking up the current to the "venous system of the human body," in that the main conductor or artery spreads out in every direction much in the same manner as the veins in the body. The capacity of lead plates constructed in this manner is very large, the lead wool giving a surface of 1.5 square meter per kilogramme of lead; every part of the mass is permeated by the fringe-like extensions of the conductor, which being of much larger section than the lead wool filaments remain firm and solid when the latter are completely peroxidized.

Lead-zinc batteries may be constructed in various forms; a convenient arrangement is the circular form which I designed with a view to strength and portability.

The zinc plate is contained in a circular porous pot, conical at the bottom so as to economize the mercury, which forms an excellent electrical connection between the copper conductors and the zinc, without the use of a soldered joint, and admits of the speedy removal of the zinc plate. In larger cells a flat zinc electrode is used, and is contained between two porous plates which are made of compressed sand and offer very little resistance to the current, because they are honeycombed in every direction, and are, in fact, too porous for primary batteries.

The outside case is made of celluloid, a material which is extremely useful for electrical purposes, in that it is unaffected by acid and can be readily moulded into any required shape; also it is much lighter than any other suitable material. For small cells I usually protect the celluloid by a wicker-work covering, but in larger kind, when they have to be removed for charging, a very light and strong receptacle is made by placing the celluloid in a loose fitting wooden box, and running an insulating material between the two, which effectually takes off any jar that might injure the interior cell. I have found that the most suitable material is a compound known as Phoenix varnish, in that it is almost as cheap as pitch and does not shrink or crack at a low temperature.

A disadvantage attending the use of a lead-zinc battery has been often quoted, namely, that there is a greater fall of electromotive force than with a lead-lead couple. This is not a serious objection, even for lighting purposes, if the discharge is not pushed too rapidly; for driving motors, electrical welding, and other new methods to which secondary batteries may be applied, a fall of electromotive force is of little consequence, and is more than compensated for by the gain of nearly 25 per cent. in the E.M.F. M. Bailly states that he has obtained an output of nearly five times as much from a lead-zinc battery of similar surface to a lead-lead without lowering the E M. F. below two volts; he has also obtained 28 ampere-hours per kilogramme of peroxidized plate, or 0.08lb. per ampere-hour. In practice I have not obtained so good a result, the average output being 0.13 lb. per ampere-hour, which, however, compares very favorably with other batteries.

In the early days of accumulators it was seriously proposed to distribute electricity by their use in the same manner as milk. The all-important factor of the difference in weight of the empty milk cans—as compared with the empty batteries—was apparently forgotten, and the public quickly found this out, although there is a story that a railway company were satisfied with this statement that a set of batteries were empty, and, therefore charged the carriage at the returned empty rate.

It would not, however, be practicable for a few people living in the neighborhood to arrange to take a supply of electricity for lighting their principal rooms, as a small set of batteries on the plan I have here could be easily delivered.

This basket contains six cells or bottles, the total weight being under 1 cwt., so that the whole can be carried by one man. The capacity of each cell is 60 ampere-hours, and a sufficient number of lamps can be maintained to light a dinner table.

There is a great want at the present time for a small portable battery for railway carriage lighting, to be used as a reservoir for maintaining the lamps when the carriages are uncoupled for the purpose of making up the train. The successful illumination of railway trains by electricity has been practically demonstrated by the North-Western and other companies, which have had trains electrically lighted for some years. The plan which appears to give the best results is to fix a small dynamo and high-speed engine either on the locomotive or back of the tender, giving the driver control of the apparatus, so that he can readily start it from the foot plate. The only objection has been the impossibility of disconnecting the carriages without extinguishing the light. A battery on the plan I have described would not occupy more space than the receiver which is usually employed with the oil gas system, and would be far safer in every way.

The immunity from accident on our well managed railways is probably the reason that some fearful disaster has not before this attended the use of compressed gas. Railway passengers are ignorant of the dangerous nature of the illuminant, which is generally stored in steel cylinders under the carriages, although these cylinders are amply strong enough to resist the enormous pressure of the gas, but would be easily perforated in the event of a collision, with the result that the liberated gas mixing with air would either explode or, in all human probability, cause a dangerous fire.

If such an accident occurred in a tunnel—for instance, on the underground railway, where the system is generally adopted—there is the additional danger of suffocation from the escaping gas, which would occupy a very large volume of space. An accident took place quite recently on the Berlin Potsdam railway which ought to act as a warning. An empty goods train ran into a passenger train, piercing the gas cylinder. The liberated gas, being set on fire by the goods engine, flew about in all directions, setting fire to everything in the carriage, in which there were three persons, who, before they could escape, were burnt to cinders. It is stated in the official account that the only remnant of the male passenger was "the buttons on his waistcoat." The gas receiver was a long sheet iron drum placed transversely under a second-class carriage.

It is needless to say that with electric light no such accident could happen, and as the employment of the compressed gas appears to offer the chance of either "cremation or suffocation," it would be far better for the railway companies to improve their existing oil lamp system until they can see their way to universally adopt the electric light.

REVISION OF THE PATENT LAW.[1]

BY C. A. BROWN.

THE business in which most of us are engaged, viz., that allied in some way to the manufacture and introduction of electrical apparatus, touches the law at many points. First, there is the patent law which prohibits the manufacture, sale or use of apparatus infringing on the monopoly given by the government to the patentee of anything new and useful. Then after you have made something which you are willing to guarantee is no infringement on any man's patent—no matter what some competitor may say—you meet, besides the laws relating to contracts, the more complicated questions regarding the powers of city authorities, perhaps, and last of all when you have made your apparatus, secured your contract in the proper form, and installed your plant, you meet the laws framed, so it is said, to enable people to avoid paying their just debts. We shall surely not go amiss then, if for one evening we turn from the consideration of mechanical electrical contrivances to discuss interests less physical in their character.

The subject which will be briefly presented in this paper is the patent law and its proposed amendment. Special interest attaches to this subject just now, as you are all aware, because an effort is being made, backed by the authority of the National Electric Light Association, to have a patent commission established. At the approaching electric light convention an effort will doubtless be made to take some final action in this matter, and it is in part with the view of having such of our members as shall attend this convention prepared to take intelligent action on this question that this paper on this subject is presented.

The bill which will be introduced into the fiftieth Congress and to assist in securing the passage of which we have all been or will be asked to contribute, is as follows:

A BILL CREATING A COMMISSION TO EXAMINE AND REPORT TO CONGRESS NEEDFUL REFORMS IN THE PATENT LAW.

"*Whereas*, The patent laws of the United States are deemed to be in such condition as to require revision; therefore,

"*Be it enacted*, by the Senate and House of Representatives of the United States in Congress assembled:

"Section 1. That a commission be, and the same is hereby created, to consist of three suitable persons to be appointed by the President of the United States, who shall hold office until a final report of this commission is submitted to and accepted by Congress, and who shall receive for their service a compensation of $5,000 each per annum.

"Sec. 2. It shall be the duty of this commission to examine thoroughly the patent laws of the United States, and those of other countries, and their practical operation and effect, in meeting the needs of the public and fulfilling the purposes for which they were created; to formulate a report to be submitted to Congress which shall set forth the results of this investigation and their conclusions therefrom, with reference to changes in, or additions to, the present law pertaining to patents. The report shall also contain a draft of an act which will provide for the changes found necessary by the investigations of the commission.

"Sec. 3. The commission is authorized to employ such clerical force as may be necessary for the proper conduct of its work and to incur such other expenses for stationery, printing, etc., as may be found expedient.

"Sec. 4. The salaries of the members of this commission as

1. Read before the Chicago Electric Club, January 16, 1888.

well as all expenses legitimately incident to its work, shall be paid from the surplus in the United States treasury to the credit of the patent office. All expenditures by or for said commission, other than the salaries of the members, shall, however, be under the control of and authorized by the Secretary of the Interior."

When this bill is introduced into the fiftieth Congress is it not likely that some congressman will ask, "If some one knows that the patent law needs revision why doesn't he point out in what respect the revision is necessary?" If this congressman should be "a terrible granger from the west," to use an expression of Mr. Walker in his speech at a recent meeting of the American Institute of Electrical Engineers, will he not go on and exclaim, "Fifteen thousand dollars a year and expenses to investigate the English and French, the German and Russian, the Swiss and Dutch patent laws and their practical operation!" (We are all aware that patent laws in Switzerland and Holland are like snakes in Ireland—there aren't any.) He will ask further, "Why can't we use the investigations which have already been made and the reports which have already been rendered about the foreign patent systems? Such reports are found in numerous books." And then he may assert that this commission scheme is a device of protectionists to reduce the surplus without reducing the tariff, and thus will be blighted the hope of those who favor this bill on the ground that it will allay the suspicions of Congress as to the ulterior motives of its promoters. It may seem to some misguided granger that the advocacy of a bill proposing three $5,000-a-year jobs is in itself proof of an ulterior motive.

There is no dispute as to the advisability of a revision of the patent law in some respects. Mr. Steuart and others have pointed out numerous features which require change. Some of the faults that are found with the law are rather fanciful, but whatever they are can anyone say that it would be more difficult to have them remedied by applying directly to Congress than it would be for instance, to secure the enactment of the proposed law creating a commission? And then we have to take the risk of the commission not being able to accomplish any good, and the possibility that the commission may consist of men who will do the patent law more harm than good.

Without claiming that we have "nothing to do with abroad," with entire willingness to learn whatever may be learned from foreign patent systems, and with due acknowledgment of the fact that the patent law of the United States is the offspring of the system of Great Britain, we can justly claim that our patent system is superior to that of any other country, both theoretically and practically, and a glance at the history of our patent law will show that it is not impossible, even without the aid of a commission, to amend it as occasion requires.

The constitutional provision for patents is contained in Article I., Section 8, of the fundamental law of the nation: "The Congress shall have power to promote the progress of science and the useful arts by securing for limited times, to authors and inventors, the exclusive right to their respective writings and discoveries."

The first patent law, which was approved April 10, 1790, and has been amended and changed many times since without radical departure from the system originally founded, prescribed a petition to the secretary of state, the secretary of war and the attorney-general and demanded a fee of five dollars. February 21, 1793, the act of 1790 was repealed and a new one was passed permitting the merger of existing state grants in regular national patents, and raising the fee to $30. By act of July 4, 1836, the patent office and the office of commissioner of patents were created; patents ran for 14 years, conditionally extensible for seven more; provision was made for examination into the novelty of the alleged invention; the fee for citizens was kept at $30 with a drawback of $20 if the patent was not allowed. The act of August 29, 1842, made designs patentable. The act of March 2, 1861, abolished extensions and made the term of patents 17 years; the application fee was made $15, and the final fee $20. Later acts are substantially codifications of the act of 1861, as modified by the construction which courts have put upon it.

In the discussion, at a recent meeting of the American Institute of Electrical Engineers, in New York, of the question of the expediency of agitating patent law revision now, in view of the hostility to the patent system which might be brought into active exercise, Mr. Phelps gave expression to the foreboding that an effort might be made to sweep away the entire patent system. George Ticknor Curtis asked if it would not be necessary to strike out part of the constitution to reach that? Mr. Phelps very cleverly and acutely replied by asking Mr. Curtis if the provision in the constitution were not that Congress *may*.

This question of Mr. Phelps brings out very clearly a point that is worthy of careful attention, viz., the reason, as presented in the language of the constitution, why patents are granted. These reasons are not the ones that popular understanding supposes them to be. The belief is general that inventors have a natural right to the exclusive use of their inventions, and that the chief end and aim of the law is to give reward to the inventors. Such is not the case; an inventor has no natural right to the exclusive use of his invention. As a learned judge has said: "An inventor has no right to his invention at common law. He has no right of property in it originally. The right he derives is a creature of the statute and of grant, and is subject to certain conditions incorporated in the statutes and in the grants. If to-day you should invent an art, a process or a machine, you have no right at common law, nor any absolute natural right, to that for seven, ten, fourteen, or any given number of years against him who invents it to-morrow, without any knowledge of your invention, and thus cut me and everybody else off from the right to do to-morrow what you have done to-day. There is no absolute or natural right at common law, that I, being the original and first inventor to-day, have to prevent you and everybody else from inventing and using to-morrow or next day the same thing.

"If an inventor has a natural exclusive right for his invention for one moment, he has it forever; and if any limit of time can be set to such a right, only infinite wisdom is adequate to the task. To state the doctrine of natural right thus is to show that it does not exist. The law has never recognized the doctrine of natural right for it can not recognize what does not exist.

"The constitution of these United States gives Congress power to enact laws for a definite purpose, which is 'to promote the progress of science and the useful arts,' and the means to be used are, 'by securing for limited terms to authors and inventors the exclusive right to their respective writings and discoveries.'"

The reason for enacting patent statutes is clearly stated in the fundamental law, but I submit that there is nothing in this fundamental law that renders it imperative on Congress to enact patent statutes, or to prevent Congress from sweeping away at once, constitutionally, all patent statutes that have been enacted. The safeguards of the present system are its wisdom and beneficent results.

It is estimated that at present one-half of the important inventions the world over originate in the United States. The records of our Patent Office are sought for and studied by the inventors and scientists of every nation, and the wisdom of our advanced policy is almost universally admitted by men of the best intelligence. Sir William Thomson said in 1876, "If Europe does not amend its patent laws, America will speedily become the nursery of important inventions for the world."

Generally speaking, foreign patent systems differ from the American in not requiring an exhaustive preliminary examination of the invention as to novelty and utility before issuing the patent, in collecting annual taxes on patents, and in requiring the invention to be worked within a given period.

I have gone briefly and cursorily into the history and policy of our patent system to show that it is the product of wisdom and the result of mature and deliberate consideration. It can be improved, but not by any ill-considered action, and it is to be hoped that wise counsel will prevail when this subject is under consideration by the National Electric Light Association. Some of the reasons why the proposed bill should not receive the final sanction of that body are:

First.—The unnecessary risk of having a commission which may be composed of men ignorant of or inimical to the present patent system.

Second.—The questionable policy of agitating patent law reform at this time when there is undoubtedly a good deal of hostility to the patent system on account of the driven well patent, the barb wire fence patent, and other patents.

Third.—The difficulty of getting the question of patent law reform properly considered during the term of Congress just preceding a national election.

Fourth.—The questionable policy of going indirectly about accomplishing the reforms which are desirable, instead of appealing directly to Congress to pass such amendments as are agreed upon as necessary and proper.

Fifth.—The advisability of getting a better general knowledge among those interested, of the present system, its merits and defects, before asking that they take action in amending the system.

Sixth.—The fact that many of the wisest and most thoughtful of patent lawyers and others well versed in the patent law and its operations, are opposed to the presentation of the bill referred to. I hold that no action of this sort should be taken without practical unanimity of the members of the body which is asked to give its authority and influence to the measure.

SPECIFIC INDUCTIVE CAPACITY.[1]

BY J. HOPKINSON, M. A., D. SC., F. R. S.

THE experiments which are the subject of the present communication were originally undertaken with a view to ascertaining whether or not various methods of determination would give the same values to the specific inductive capacities of dielectrics. The programme was subsequently narrowed, as there appeared to be no evidence of serious discrepancy by existing methods.

In most cases the method of experiment has been a modification of the method proposed by Professor Maxwell, and employed by Mr. Gordon. The only vice in Mr. Gordon's employment of that

1. Read before the Royal Society on Thursday, November 17, 1887.

method was that plates of dielectrics of dimensions comparable with their thickness were regarded as of infinite area, and thus an error of unexpectedly great magnitude was introduced.

For determining the capacity of liquids, the apparatus consisted of a combination of four air condensers. with a fifth for containing the liquid arranged as in a Wheatstone bridge, figure 1. Two, E F, were of determinate and approximately equal capacity, the other two, J I, were adjustable slides, the capacity of either condenser being varied by the sliding part. The outer coatings of the condensers E F, were connected to the case of the quadrant electrometer, and to one pole of the induction coil, the outer coatings of the other pair, J I, were connected to the needle of the electrometer and to the other pole of the induction coil. The inner coatings of the condensers J F were connected to one quadrant, and I E to the other quadrant of the electrometer.

The slide of one or both condensers, J I, was adjusted till upon exciting the induction coil no deflection was observed on the electrometer. A dummy was provided with the fluid condenser, as in my former experiments, to represent the necessary supports and connections outside of the liquid. Let now x be the reading of the sliding condenser when no condenser for fluid is introduced, and a balance is obtained. Let y be its reading when the condenser is introduced fitted with its dummy, z, when the full condenser is charged with air. Let z_1 be the reading when the condenser charged with fluid is introduced, then will K, the specific inductive capacity of the liquid, be equal to $(y - z_1)\ 1\ (y - z)$.

Three fluid condensers were employed, one was the same as in my former experiments.[1] Another was a smaller one of the same type arranged simply to contain a smaller quantity of fluid. The third was of a different type, designed to prove that by no chance did anything depend on the type of condenser; this done it was laid aside as more complicated in use.

To determine the capacity of a solid, the guard-ring condenser

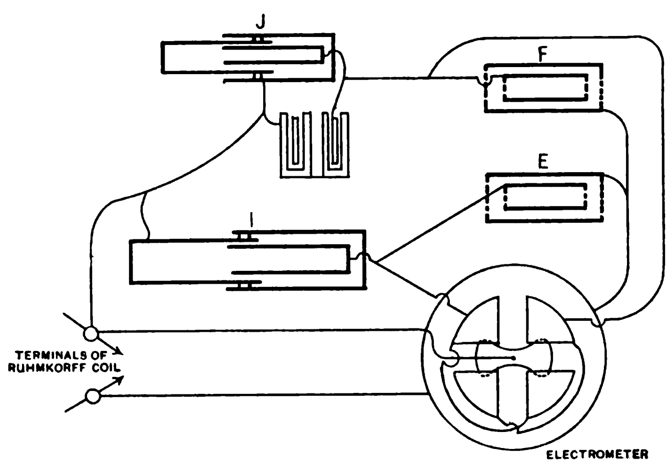


Fig.1.

of my previous experiments[2] was used. Advantage was taken of the fact that at the time when there is a balance the potentials of the interiors of all the condensers are the same. Let the ring, O, of the guard-ring condenser be in all cases connected to J, let the inner plate of the guard ring be connected to J, as in figure 2, and let a balance be obtained. Let the inner plate be now transferred to I, as in figure 3, and again let a balance be obtained; the difference of the two readings on the slide represents on a certain arbitrary scale the capacity of the guard-ring condenser at its then distance.

In some cases it was necessary to adjust both condensers to obtain a balance, then the value of a movement of the scale of one condenser in terms of the other was known from previous experiment. In some cases it was found most convenient to introduce a condenser of capacity known in divisions of the scale of the sliding condenser coupled as forming part of the condenser J. The old method of adding the opposite charges of two condensers, then connecting to the electrometer and adjusting until the electrometer remained undisturbed was occasionally used as a check; it was found to give substantially the same results as the method here described when the substance was insulated sufficiently well to give any results at all.

Colza Oil.—This oil had been found not to insulate sufficiently well for a test by the method of my former paper. Most samples, however, were sufficiently insulating for the present method. Seven samples were tested with the following mean results :—

No. 1. This oil was kindly procured direct from Italy for these experiments by Mr. J. C. Field, and was tested as supplied to me—

K = 3.10.

No. 2 was purchased from Mr. Sugg, and tested as supplied—

K = 3.14.

No. 3 was purchased from Messrs. Griffin, and was dried over anhydrous copper sulphate—

K = 3.23.

No. 4 was refined rape oil purchased from Messrs. Pinchin and Johnson, and tested as supplied—

K = 3.08.

No. 5 was the same oil as No. 4, but dried over anhydrous copper sulphate—

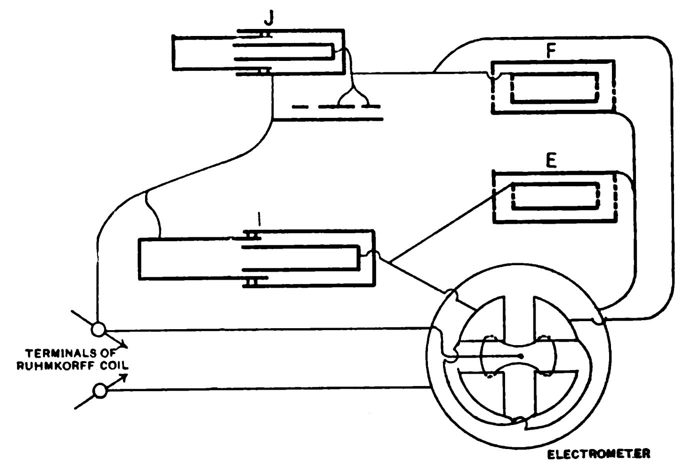


Fig.2.

K 3.07.

No. 6 was unrefined rape purchased from Messrs. Pinchin and Johnson, and tested as supplied, the insulation being bad, but still not so bad as to prevent testing—

K = 3.12.

No. 7. The same oil dried over sulphate of copper—

K = 3.09.

Omitting No. 3, which I cannot indeed say of my own knowledge was pure colza oil at all, we may, I think, conclude that the specific inductive capacity of colza oil lies between 3.07 and 3.14.

Professor Quincke gives 2.385 for the method of attraction between the plates of a condenser, 3.296 for the method of lateral compression of a bubble of gas. Palaz[3] gives 3.027.

Olive Oil.—The sample was supplied me by Mr. J. C. Field—

K = 3.15.

The result I obtained by another method in 1880 was 3.16.

Two other oils were supplied to me by Mr. J. C. Field.

Arachide.—K = 3.17.

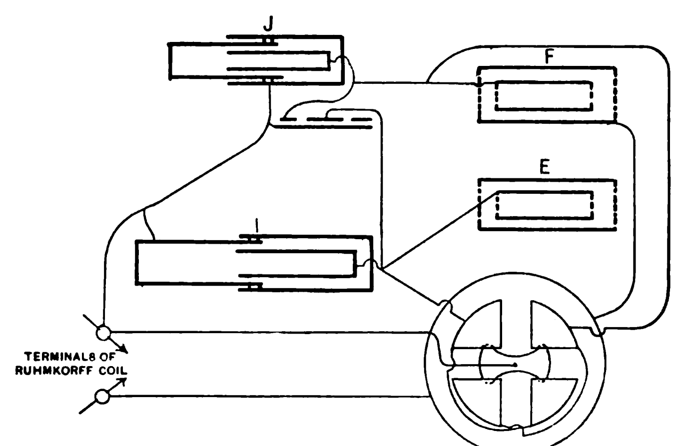


Fig.3.

Sesame.—K = 3.17.

A commercial sample of *raw linseed oil* gave K = 3.37.

Two samples of *castor oil* were tried; one newly purchased gave K = 4.82; the other had been in the laboratory a long time, and was dried over copper sulphate—

K = 4.84.

The result of my earlier experiments for castor oil was 4.78; the result obtained subsequently by Cohn and Arnos[4] is 4.48. Palaz gives 4.610.

1. "Phil. Trans.," 1881, part ii.
2. "Phil. Trans.," 1878, part i.
3. *La Lumière Electrique*, vol. 21, 1886, p. 97.
4. "Wiedemann's Annalen," vol. 28, p. 474.

Ether.—This substance as purchased, reputed chemically pure, does not insulate sufficiently well for experiment. I placed a sample purchased from Hopkin and Williams as pure, over quicklime, and then tested it. At first it insulated fairly well, and gave K = 4.75. In the course of a very few minutes K = 4.93, the insulation having declined so that observation was doubtful. After the lapse of a few minutes more observations became impossible. Professor Quincke in his first paper gives 4.623 and 4.660, and 4,394 in his second paper.

Bi-sulphide of Carbon.—The sample was purchased from Hopkin and Williams, and tested as it was received—

K = 2.67.

Professor Quincke finds 2.669 and 2.743 in his first paper, and 2.623 in his second. Palaz gives 2.609.

Amylene.—Purchased from Burgoyne and Company—

K = 2.05.

The refractive (μ) index for line D is 1.3800,

$\mu^2 = 1.9044$.

Of the benzol series four were tested: *benzol, toluol, xylol,* obtained from Hopkin and Williams, *cymol* from Burgoyne and Company.

In the following table the first column gives my own results, the second those of Palaz, the third my own determinations of the refractive index for line D at a temperature of 17.5° C., and the fourth the square of the refractive index:—

			μ	μ^2.
Benzol......	2.38	2.338	1.5038	2.2614
Toluol......	2.42	2.365	1.4990	2.2470
Xylol........	2.39	——	1.4913	2.2238
Cymol	2.25	——	1.4918	2.2254

For benzol Silow found 2.25, and Quincke finds 2.374.

The method employed by Palaz is very similar to that employed by myself in these experiments; but, so far as I can ascertain from his paper, he fails to take account of the induction between the case of his fluid condenser and his connecting wire; he also supports the inner coating of his fluid condenser on ebonite; and, so far as I can discover, fails to take account of the fact that this also would have the effect of diminishing to a small extent the apparent specific inductive capacity of the fluid. Possibly this may explain why his results are in all cases lower than mine. Determinations have also been made by Negreano ("Comptes Rendus," vol. 104, 1887, 423) by a method the same as that employed by myself.

Three substances have been tried with the guard-ring condenser—double extra condensed flint glass, paraffine wax, and rock salt. The first two were not determined with any very great care, as they were only intended to test the convenience of the method. For double extra dense flint glass a value 9.5 was found; the value I found by my old method was 9.896. For paraffine wax 2.31 was obtained—my previous value being 2.29. In the case of rock salt the sample was very rough, and too small; the result was a specific inductive capacity of about 18, a higher value than has yet been observed for any substance. It must, however, be received with great reserve, as the sample was very unfavorable, and I am not quite sure that conduction in the sample had not something to do with the result. In the experiments with the guard-ring condenser the disturbing effect of the connecting wire was not eliminated. My thanks are due to my pupil, Mr. Wordingham, for his valued help in carrying out the experiments.

ABSTRACTS AND EXTRACTS.

THE RADIAL DISTRIBUTION OF VARIABLE CURRENTS IN THICK WIRES.

THE question of the radial or sectional distribution of variable—and more especially of alternating—currents in conductors of large size is one upon which it will generally be confessed that very little light has dawned as yet upon the average electrician. It is usually, and vaguely, understood that—apart altogether from impedance—there exists a phenomenon by reason of which a given conductor when traversed by an alternating current of given mean square value presents a higher resistance, or causes a greater dissipation of energy, than when traversed by a continuous current of corresponding strength. It is, as a rule, still more vaguely held that this effect is due to a kind of tangential tendency, by reason of which the current density is greater in the exterior than in the interior layers of the conducting wire. The fundamental treatment of the subject is, of course, dealt with by Clerk-Maxwell (*cela va sans dire*); the question has also been experimentally as well as mathematically investigated by Lord Rayleigh (see *The Electrician*, vol. xviii., p. 170, *et seq.*). But hitherto no very tangible conception of the nature of this phenomenon has been placed within the reach of the non-mathematical reader.

We are indebted to a paper read before the Austrian Academy by Professor Stefan for a simple and intelligible exposition of the kind of action which takes place. Professor Stefan conveys his explanation by the aid of analogy. Imagine, he says (in effect), a cylinder or cylindrical wire heated throughout to a uniform temperature; let it suddenly be brought into a chamber where the temperature is higher. What will take place? Obviously the outer layers of the cylinder will first rise in temperature and gradually convey heat to the successive interior layers.

Precisely the same order of phenomena occurs if an E. M. F. is suddenly set up between the two ends of the wire or cylinder. The current during the so-called variable state passes first through the outer layers alone, and gradually (using this word in a relative sense) penetrates the inner layers. When the external E. M. F. is suddenly removed, and during the gradual cessation of current due to self-induction of the conductor, the action resembles, on the contrary, the cooling of a uniformly heated wire on passing into a colder medium—that is to say, the current ceases first, or rather *most quickly*, in the outer layers. Now, imagine that the wire is rapidly transferred to and fro between a hotter and a colder medium. It is quite easy to see not only that waves of heat will pass radially to and fro, but moreover that its condition at any moment depends very largely upon the *rapidity* of the rate of transference. When the rate of motion is sufficiently slow, the waves of heat passing any given point in the radius of the wire follow exactly with the periodic changes of position. The *amplitudes* of these variations have values which decrease from the surface inwards. When the rate of change is increased the amplitudes of the waves get shorter and shorter, and at an infinite velocity the wire would acquire an equable temperature throughout.

The electrical analogue is obvious from what has been already said, the rate of transfer corresponding to the inverse of the periodic time of an alternating current, the heat *conducting* power of the material corresponds to the electric *resistance*. But there is also the inductance of the wire, which plays a part opposed to that of the electric resistance, and which scarcely seems to have any distinct analogy in the heat system.

Professor Stefan gives some numerical illustrations which are valuable to fixed ideas, though many more will be found in the paper of Lord Rayleigh already referred to. With an *iron* wire of 4mm. diameter, and a periodic time of one 250th sec., the amplitude of the waves of current density is about twenty-five times as great upon the surface as at the axis of the wire. For double the number of vibrations per second the external amplitude becomes only six times as great. The difference of the phases is one-third the duration of the vibration in the first case and one-half in the second. The latter statement implies that the external current is at a given moment actually in the reverse direction to the internal current. For non-magnetic wires the difference is not nearly so marked, and it decreases also as the specific resistance increases. For a copper wire of 4mm. diameter with periodic time of one 500th sec. the difference between the current density at the surface and in the centre is only 14 per cent. If, however, the copper wire be increased to 20mm. diameter then we should get the same difference as in the particular iron wire above quoted.

It is obvious that the result of this non-homogenous distribution of the current is to increase the rate of dissipation of energy, which is, of course, proportionate in each transverse section to the square of the current in that section. In the case of the iron wire referred to above, augmentation of resistance is 48 per cent. at the lower rate of alternation and 100 per cent. at the higher. The resultant effect upon the self-induction is, however, to diminish the value of the coefficient. From this follows the apparent paradox that although the effective resistance is increased by the non-homogenous distribution of current, yet, under the same E. M. F., the current may for the same reason be greater. The effect in decreasing the resultant self-induction coefficient is more marked as the periodic time is lessened, until at length the decrease of impedance from this cause may have a most important influence in increasing the current.—*The Electrician* (London).

PRESENT POSITION AND PROSPECTS OF THE ELECTRIC LIGHTING INDUSTRY.

BY PROFESSOR EWING.

IN October last, Professor Ewing gave the first of a course of ten popular lectures on electric lighting in the engineering class room of University College, Dundee, the subject of the introductory lecture being "The Present Position and Prospects of the Electric Lighting Industry." After some preliminary remarks the lecturer went on to speak of the progress in electric lighting during the last five years, under the several heads of production of electricity, storage, distribution, and lamps. The apparatus was now vastly more efficient and very much cheaper. Doctor Fleming had lately shown that the first cost of a large dynamo was then about £2 per lamp; now it was only 7s. Lamps were now more durable. Storage batteries are trustworthy and permanent. By transformers it had become possible to convey

electric energy in the form of a current of small quantity at great pressure, thereby requiring only small conductors, and then converting that into currents of large quantity and low pressure, suitable for ordinary domestic use. By this means the problem of economically distributing electricity for incandescent lighting from a central station was in a fair way to be solved, and in the last year Mr. Westinghouse had put up 27 such stations. The electric meter of Professor Forbes, made public only last September, would serve to show how much electricity each householder was consuming, just as a gas meter did for gas. Apart from the question of general distribution from central stations, the electric light was now an assured success as the illuminant of large open spaces, of ships, of exhibitions, of theatres, of the country mansions of the rich, and of mills and factories. The question that determined the use of the electric light was almost wholly a question of cost. Was it or was it not cheaper than gas? To that question it was now possible to give a definite answer. Supposing, as was often the case in Dundee mills, the power required could be taken from the mill engine, then whenever night work was to be done, electric lighting by incandescent lamp was unquestionably cheaper than gas. If there was only day work—that is, if light was required only for a few hours in the early morning and the late afternoon of the winter months—then gas and electricity ran almost neck and neck as regards cost; but if light was wanted for anything like a thousand hours in the year, then electricity was distinctly cheaper, even allowing in the most liberal way for interest and depreciation on the permanent plant, as well as for the cost of lamp renewals, coal, oil, etc. More than two years ago he pointed this out in a lecture in Dundee as the result of a calculation, and shortly after he had the opportunity of making practical proof in mills in the Dundee district, where he had been consulted professionally regarding the electric light. In one of these factories the calender was lighted by electricity, and was used occasionally for night work. After two years' use the manager had given him figures for the actual cost. For 1,200 hours' work during one year the whole cost of lighting by electricity, including interest and depreciation, was under £50. The same area had formerly been lighted by gas, and the gas bill for the same number of hours' work had been £82. If the plant had been of the most modern kind, the difference would have been still greater in favor of electricity. In another case, in the underground warehouse of a Dundee mill, where they had formerly made shift to work with the dimmest light for fear of fire, the electric light had been introduced under his supervision, and the results had been very interesting. He recommended that, as a brilliant light was not wanted, the lamps should be worked, for the sake of economy, at a low degree of incandescence. This had been done, and some of the lamps, burning every working day for ten hours, had lasted for more than 7,000 hours. Their average life had been 5,500 hours. In conclusion, the lecturer said there were many signs that the electric light industry, after a long time of great depression—during which, however, the engineers had not been idle—was about to enter on a period of rapid growth.—*The Electrician* (London).

DR. BALFOUR STEWART, F. R. S.

In the genial Manchester Professor the scientific world has lost not only an excellent teacher of physics but one of its ablest and most original investigators. He was trained according to the best methods of the last generation of experimentalists, in which scrupulous accuracy was constantly associated with genuine scientific honesty. Men such as he was are never numerous; but they are the true leaders of scientific progress :—*directly*, by their own contributions ; *indirectly*, though (with rare exceptions) even more substantially, by handing on to their students the choicest traditions of a past age, mellowed by time and enriched from the experience of the present. The name of Stewart will long be remembered for more than one striking addition to our knowledge, but his patient and reverent spirit will continue to impress for good the minds and the work of all who have come under its influence.

He was born in Edinburgh on November 1, 1828, so that he had entered his sixtieth year. He studied for a short time in each of the Universities of St. Andrews and Edinburgh, and began practical life in a mercantile office. In the course of a business voyage to Australia his particular taste for physical science developed itself, and his first published papers :—"On the adaptation of the eye to different rays," and "On the influence of gravity on the physical condition of the moon's surface," appeared in the *Transactions of the Physical Society of Victoria* in 1855. On his return he gave up business for science, and resumed study under Kelland and Forbes, to the latter of whom he soon became assistant. In this capacity he had much to do with the teaching of natural philosophy on occasions when Forbes was temporarily disabled by his broken health. During this period, in 1858, Stewart was led to his well-known extension of Prévost's *Law of Exchanges*, a most remarkable and important contribution to the theory of radiation. He seems to have been the first even to suggest, from a scientific standpoint, that radiation is not a mere surface phenomenon. With the aid of Forbes's apparatus, then perhaps unequaled in any British University, he fully demonstrated the truth of the conclusions to which he had been led by theory ; and the award of the Rumford medal by the Royal Society some years later, showed that his work had been estimated at its true value, at least in the scientific world. In fact his proof of the necessary equality between the radiating and the absorbing powers of every substance (when divested of some of the unnecessary excrescences which often mask the real merit of the earlier writings of a young author) remains to this day the simplest and therefore the most convincing that has yet been given.

Radiant heat was, justly, one of Professor Forbes's pet subjects, and was therefore brought very prominently before his assistant. Another was meteorology, and to this Stewart devoted himself with such enthusiasm and success that in 1859 he was appointed director of the Kew Observatory. How, for eleven years, he there maintained and improved upon the memorable labors of Ronalds and Welsh needs only to be mentioned here—it will be found in detail in the *Reports of the British Association*. Every species of inquiry which had to be carried out at Kew, whether it consisted in the testing of thermometers, sextants, pendulums, aneroids, or dipping-needles, the recording of atmospheric electricity, the determination of the freezing point of mercury or the melting point of paraffine, or the careful study of the peculiarities of the air-thermometer, received the benefit of his valuable suggestions and was carried out with his scrupulous accuracy.

About twenty years ago Stewart met with a frightful railway accident, from the effects of which he did not fully recover. He was permanently lamed and sustained severe injury to his constitution. From the vigorous activity of the prime of life he passed, in a few months, to grey-headed old age. But his characteristic patience was unruffled and his intellect unimpaired.

His career as Professor of physics in the Owens College has been, since his appointment in 1870, brilliantly successful. It has led to the production of an excellent treatise on *Practical Physics*, in which every necessary detail is given with masterly precision, and which contains (what is even more valuable, and could only have been secured to the world by such a publication) the matured convictions of a thorough experimenter as to the choice of methods for the attack of each special problem.

His *Elementary Physics* and his *Conservation of Energy* are popular works on physics rather than scientific treatises, but his *Treatise on Heat* is one of the best in any language, a thoroughly scientific work, specially characteristic of the bent of mind of its author.

Stewart published, in addition to his *Kew Reports*, a very large number of scientific memoirs and short papers. Many of these (notably the article in the *Encyc. Brit.*, 9th ed.) deal with terrestrial magnetism, in itself as well as in its relations to the Aurora and to solar disturbances. A valuable series of papers, partly his own, partly written in conjunction with De la Rue and Lœwy, deals with solar physics. His paper on the *Occurrence of Flint Implements in the Drift* (*Phil., Mag.* 1862, i.) seems to have been ignored by the "advanced" geologists, one of whose pet theories it tends to dethrone ; and to have been noticed only by physicists, especially Sir W. Thomson, whose beautiful experiments have done so much to confirm it. His paper on *Internal Radiation in Uniaxial Crystals*, to which Stokes alone seems to have paid any attention, shows what Stewart might have done in mathematical physics had he further developed the genuine mathematical power which he exhibited while a student of Kelland's.

I made Stewart's acquaintance in 1861, when he was the first-appointed additional examiner in mathematics in the University of Edinburgh, a post which he filled with great distinction for five years. A number of tentative investigations ultimately based upon our ideas as to possible viscosity of the luminiferous medium, effect of gravitation-potential on the physical properties of matter, etc., led to the publication of papers on *Rotation of a disc in vacuo*, *Observations with a rigid spectroscope*, *Solar spots and planetary configurations*, etc. These, as well as our joint work called *The Unseen Universe*, have been very differently estimated by different classes of critics. Of course I cannot myself discuss their value. There is, however, one of these speculations so closely connected with Stewart's radiation work as to require particular mention, especially as it seems not yet to have received proper consideration, viz. *Equilibrium of Temperature in an enclosure containing matter in visible motion.* (*Nature*, 1871 ; iv. 331.) The speculations are all of a somewhat transcendental character, and therefore very hard to reduce to forms in which they can be experimentally tested ; but there can be no doubt that Stewart had the full conviction that there is in them all an underlying reality, the discovery of whose exact nature would at once largely increase our knowledge.

Of the man himself I cannot trust myself to speak. What I *could* say will easily be divined by those who knew him intimately, and to those who did not know him I am unwilling to speak in terms which, to them, would certainly appear exaggerated.—P. G. TAIT, in *Nature*, Dec. 29, 1887.

MR. EDISON ON THE PATENT LAW.

MR. EDISON said recently, when questioned as to the patent rights in the phonograph: "I always thought that my original patent of twelve years ago covered the essential features of the phonograph so completely as to give me a monopoly of the perfected instrument whenever I, or any one else, should find time to finish it. Within the last few years, however, I have become extremely skeptical as to the value of any patent, and so long as our patent law remains in its present iniquitous shape, I shall try to do without patents. The present law is a constant temptation to rascals, and virtually offers a premium upon rascality. Under it the infringer of a patent is not interfered with until the real owner can show that he has the monopoly of the device in question. This process may take years, during which the infringer, who has money and audacity enough to seize another man's invention, can go on and perhaps wear the rightful owner's life out by litigation and annoyance. I have had so much of this sort of thing within the last five years, that I have almost made up my mind never to take out another patent until the law is changed. The burden of proof is now put entirely upon the man who holds the patent instead of upon the man who wishes to infringe it, whereas it ought to be all the other way.

"There is scarcely an invention of importance made within the last generation which has not been disputed upon frivolous grounds, and the inventor put to all sorts of annoyance. In my own case. I am sure that no matter what I may patent, some one will come up as soon as the patent is seen to have any value, and show, by dozens of witnesses if necessary, that he is the rightful owner of the invention. If I patent to-morrow a process for making good flour at a cost of two cents a barrel, the publication of my patent would bring out about ten men who could prove that they did that sort of thing years ago, and that I had no right to a patent. In the case of my dynamos, I have patents by the score, and yet when a great firm of machinists want to go into the business of making dynamos, they coolly appropriate one hundred of my inventions, and laugh at my claims as patentee. To litigate the matter to the end, if there was any end in sight, would cost hundreds of thousands of dollars, and put me in hot water for years to come. I am an inventor and not a lawyer, and I hate litigation. If patents are going to give me nothing but lawsuits, I don't want any more of them.

"In the case of the phonograph, these Washington people have had the decency to come here to Orange and ask for my permission to manufacture and sell their devices; they wanted a license, which I refused to give them. Having no license, they go to work at once and proclaim the worthlessness of all patents upon the phonograph except their own; they have got some patents for twisting a screw to the right instead of the left, etc. I really can't say what our first steps will be, and I leave all those matters to the lawyers, who enjoy that sort of business. Certainly if the phonograph turns out to be the great commercial success that I expect for it, there will be a dozen infringements upon the market within the next six months, and the lawyers will have their hands full.

"I am so thoroughly convinced of the uselessness of patents, that one of my objects in building my present laboratory is to search for trade secrets that require no patents, and may be sources of profit until some one else discovers them. There are scores and scores of such secret processes, which are enormously profitable and which are not claimed right and left, just because they are secrets. Some are used in this country, but most of them, chiefly chemical, are held in Europe. Methods of dyeing, of working certain fabrics, etc., pay millions every year to those who know the secret processes employed. I have already found one chemical device which promises to pay me handsomely, and the patent-office will never hear anything about it. To apply for a patent would simply invite a lot of rogues to share with me, or, what is more likely, to take all the profits. I am rather curious to see what is to be done when the phonograph comes out. The patent has only five years to run, and evidently, if men with millions behind them jump into the manufacture upon a large scale, the patent may run out before my claim to the fundamental device is allowed."—*N. Y. Evening Post.*

COPPER PRODUCTION IN 1887.

THE *Engineering and Mining Journal* gives an elaborate review of copper production and trade in 1887, and places the production of this country at 177,200,000 pounds, against 156,735,381 pounds in 1886, and 165,875,766 pounds in 1885. It estimates the consumption of copper in 1887 at 140,500,000 pounds, exports at 45,000,000 pounds, and the stock on hand Jan. 1, 1888, at 27,000,000 pounds, against 30,000,000 pounds Jan. 1, 1887. It estimates the output of the Lake Superior mines in 1888 at not exceeding 85,000,000 pounds, and the Montana output at not exceeding 90,000,000 pounds, and the output of all mines in this country at 200,000,000 to 210,000,000 pounds. It puts the average price of lake copper in New York at 11¼c., the range being from 10c. in May and June to 17c. in December. Here is its estimate of the copper production of the United States in 1887, from complete and partial returns;

	Pounds.
LAKE MINES.	
Calumet & Hecla	45,600,000
Quincy	5,502,000
Osceola	3,565,000
Franklin	3,924,000
Allouez	885,000
Atlantic	3,550,000
Central	2,000,000
Copper Falls	560,000
Phœnix	11,000
Huron	1,471,000
Ridge	85,000
Cliff	2,300
National	25,200
Tamarack	7,390,000
Kearsarge	22,000
Tributers	67,500
Total, 1887	74,660,000
Colorado	2,000,000
Other states and territories	2,400,000
Lead desilverizers	1,240,000
From foreign ores	5,300,000
MONTANA MINES.	
Anaconda	57,000,000
Parrott	10,000,000
Boston & Montana	1,500,000
Clark's Colusa	7,100,000
Butte reduction works	1,565,000
Williams	1,495,000
Other mines	240,000
Total, 1887	78,900,000
ARIZONA MINES.	
Copper Queen	5,945,550
Old Dominion	1,444,770
Arizona Copper Co	5,714,000
Detroit Copper Co	4,404,321
United Verde	272,124
Other mines	219,235
Total	18,000,000
Grand total, all mines	182,500,000

ELECTROLYSIS OF IRON SALTS.

BY ALEXANDER WATT.

(Continued from page 17.)

IT was noticed in the last paper that solutions of the perchloride and persulphate of iron yielded no deposit of metallic iron upon the cathode. It was next determined to ascertain the behavior of a solution of the pernitrate of iron, employing the liquid at various degrees of concentration, with a current from two to five small Daniell cells progressively, the cells being arranged in series. The anode, as in the former cases, consisted of a plate of wrought iron, and the cathode a strip of sheet copper.

Pernitrate of Iron.—A concentrated solution of this salt was prepared by digesting fragments of iron in a solution composed of equal parts of nitric acid and water. On the following day the solution was ready for use. To form the electrolyte, for the first trial, five fluid drachms of the pernitrate solution were added to five ounces of water. Two Daniells were used, and the electrodes then immersed, their surfaces being about equal. During the first few seconds no apparent deposit took place, so the cathode was moved about quietly, when a slight film of iron began to form. The plate was then allowed to rest for about two minutes, at the end of which time it became coated with a thick black deposit, interspersed with bubbles of hydrogen, which rested firmly on the plate. Surrounding these gas bubbles were minute glistening particles of metallic iron, which had evidently been reduced by the hydrogen. The plate was now carefully rinsed so as not to disturb the coating, and was then held over the flame of a small lamp, at a moderate distance from the flame, until the black deposit became dry on both sides of the plate. During the process of drying, the deposit suddenly broke up into minute particles, leaving the copper surface exposed. The particles were then brushed off and collected upon a piece of white paper. Upon holding a magnet below the surface of the paper the granules were powerfully attracted, proving that they consisted of metallic iron in a very finely divided state. A second plate was then immersed in the bath and allowed to rest for about five minutes, by which time it became very thickly coated with the same black deposit, which was afterwards washed, dried and collected as before. An attempt was next made to induce the metal to deposit in a reguline form, by diluting the solution considerably. In this case, as before, a slight reguline film appeared upon the copper plate when it was kept in motion, but so soon as it was allowed to remain stationary the black deposit again formed, and after a few minutes immersion it stripped off the plate (doubtless dislodged by the hydrogen bubbles) and accumulated at the bottom of the vessel. The black deposit was afterwards collected, washed and dried as before, and the resulting black dust tested with the magnet, by which it was powerfully attracted. A still weaker solution was next tried, with a precisely similar result, and the plate was allowed to remain in the bath for about 10 min-

utes, during which time the black deposit from the cathode accumulated on the surface of the liquid, nearly covering its entire surface in fact, the fine particles of iron being held in suspension by the hydrogen bubbles, with which it was intimately mixed. The solution eventually became nearly colorless, while the anode was but slightly acted upon. It should be mentioned that the evolution of gas was much more copious with the weaker than than with the stronger solutions, while in some cases bubbles of gas nearly as large as a pea rested upon the plate for at least a minute before bursting. In reflecting upon the character of the dried deposit of iron above described, it appears to me to resemble the pharmaceutical product known as *Quevenne's Iron*, which is prepared by passing a stream of dry hydrogen gas through red hot sesquioxide of iron contained in a gun barrel, the object of which is to reduce the iron in a very finely divided state, by which it may readily become dissolved by the juices of the stomach, thus forming a useful and effective chalybeate. The formation of *impalpable metallic iron* in the way I have indicated would be a far cheaper and less troublesome method than either of the processes adopted for preparing Quevenne's iron; indeed, I am disposed to think that the iron could be produced in a more finely divided state electrolytically than by the pharmaceutical methods.

Citrate of Iron.—A solution of this salt was prepared by dissolving recently precipitated carbonate of iron in a moderately strong and hot solution of citric acid, the carbonate being added a little at a time until evidence of neutralization occurred, which became known by the liquid remaining turbid after the last addition of the iron salt was made; an excess of citric acid was then given, not only to clear the liquid, but to assist the solution of the anode. The solution was used cold, and two small Daniells at first employed. A clean strip of sheet copper received a white and bright deposit of iron soon after the immersion, but as the deposit was scarcely rapid enough, a third cell was connected, when deposition took place freely upon a newly prepared plate. After two hours' immersion a good bright deposit was obtained, which thickened at the lower edges in the form of minute nodules. The film, which was of a silvery whiteness, was of a thoroughly reguline character, excessively hard, and readily attracted by the magnet. On examining the anode, it appeared to have been very freely and uniformly acted upon. Five cells were next tried, when the deposit became more rapid, but still maintained its bright and silvery lustre, being even whiter than the best Damascus steel.

Cyanides of Iron.—The various cyanide salts of iron were tried, but not one of them yielded a reguline deposit of the metal. The only solution of this class which gave a tolerably successful result was that of the sulphocyanide of iron, from which a darkish film, of an iron grey color, was obtained upon a copper plate by keeping it continually in motion; no deposit appeared to take place upon a stationary electrode. While deposition was going on under these conditions a dirty white deposit formed upon the anode which was insoluble in the liquid.

Sulphate of Iron and Chloride of Ammonium.—A solution of the mixed salts has been applied by Meidinger and others for coating copper plate with iron. For this purpose the following proportions give very satisfactory results:—Sulphate of iron, 2oz., dissolved in water 1 pint; sal-ammoniac, 1¼ oz., dissolved in water 1 pint. These solutions were mixed, and a few drops of acetic acid added. With the current from two Daniell cells, and electrode surfaces about equal, a reguline deposit of iron was obtained upon a copper plate from a bath prepared as above immediately after immersion. There was but moderate evolution of gas, and the film was exceedingly uniform and of good color, though neither so bright nor so purely white as the deposits from the simple sulphate or citrate salts. After half an hour's immersion, the coating, though otherwise faultless, assumed a dull appearance; there was no blackening at the edges of the plate, however, nor any other irregularity of the surface of an objectionable nature. There was a slight deposit of peroxide, however, which would doubtless continue to form, but since this readily finds its way to the bottom of the vessel it does not necessarily interfere with the film, provided the liquid be kept in a deep vessel and the deposited oxide allowed to remain undisturbed when immersing or withdrawing the coated plates. On examining the anode (a plate of wrought iron) it appeared to have been pretty uniformly acted upon, and exhibited the characteristic crystalline appearance of iron which has been subjected to the solvent action of weak acid solutions. The deposit upon the cathode, after one hour's immersion, had become somewhat more dull, but otherwise the coating was perfectly uniform and of good quality.

Protacetate of Iron.—A solution of this salt was prepared by dissolving freshly precipitated carbonate of iron in dilute acetic acid, of which it is a ready solvent. The carbonate of iron was added in moderate quantities at a time, until the acid became neutralized, when a small addition of free acetic acid was made, and the bath, after filtering, was ready for use. The current from three small Daniells was employed, and the surface of the positive electrode was about three times that of the cathode. Under these conditions a good white deposit was promptly obtained, the film being of a perfectly reguline character. After a short immersion of the electrodes the anode was examined, and proved to have been freely acted upon. There was a slight disposition for the deposit to blacken in the centre of the negative plate, which was remedied by immersing a larger surface of anode. The deposition was now allowed to proceed undisturbed for about two hours, at the end of which time it was found that the solution had become considerably oxidized, there being a copious deposit of peroxide of iron at the bottom of the vessel; at the same time the deposit had lost its reguline character; and became black and pulverulent, while the anode was considerably eaten away.

Sesquiacetate of Iron.—A solution of this salt was prepared by dissolving freshly precipitated hydrated sesquioxide of iron in acetic acid, the solution being afterwards moderately diluted and filtered. There was practically no deposit obtained from this solution, even when brisk motion was given to the cathode.

Ammonio-Chloride of Iron.—A bath was prepared by adding to a solution of perchloride of iron another of chloride of ammonium, the combined liquids being of moderate strength. Five cells were used, and a large anode surface exposed. On immersing the negative plate (a strip of copper) it received a partial coating of a dark color, but while the plate was stationary in the liquid there was practically no deposit. When the plate was briskly moved about a slight film appeared all over the immersed surface, which was black at the lower corners; beyond this there was no deposit obtainable. The solution was next diluted with a considerable proportion of water, when the plate became coated with a black film of iron in a finely divided state, similar to that obtained from the pernitrate, but much more slowly formed. The results, however, had no practical significance.

Oxalate of Iron.—A solution was formed by dissolving freshly precipitated carbonate of iron in a strong solution of oxalic acid. The iron salt dissolved very freely, with evolution of carbonic acid, leaving a clear solution, which was next diluted with water. With two Daniells no deposit took place upon a copper cathode while it remained stationary in the liquid; when this electrode was briskly moved about, however, a white film of iron was obtained, which gradually increased in thickness so long as the agitation was kept up. During the electrolysis the solution became decomposed, and a deposit of peroxide settled at the bottom of the vessel. Five cells were also tried, but there was no deposit of reguline metal unless the cathode was kept in brisk motion.—*The Electrician* (London).

(*To be continued.*)

CORRESPONDENCE.

NEW YORK AND VICINITY.

An Effort to Regulate Anchorage in the Vicinity of Cable Crossings in New York Harbor.—Mr. Michael Breslin.—Postal Telegraphy.—The Substitution of Electricity for the Gallows.—The American Institute of Electrical Engineers; Dr. Duncan, of Johns Hopkins University, to Read a Paper on Alternate Current Motors February 14.—The Board of Electrical Control and the Subways.—A Citizen of New Jersey tried for Cutting Down a Telegraph Pole, found "Not Guilty."—Magnetism and Watches.—Opening of the Electric Club House.

ALL electrical companies having cables across the North river should be interested in knowing that Captain John Vosburgh, of the Schuyler Towing Co., and other gentlemen have gone to Washington to secure legislation empowering the Lighthouse Board, or other proper department, to regulate the anchorage of vessels in the North river. In the absence of any regulations, the various skippers anchor to suit their own convenience, without regard to their annoyance of other people. If a reform is effected, it will no doubt prevent much future damage to cables.

Mr. Michael Breslin, who has been chief batteryman for the Gold and Stock Telegraph Co. since its organization twenty years ago, has recently been elected treasurer of District 49, K. of L. Mr. Breslin has also held for several years the office of treasurer of the Gold and Stock Life Insurance Association. He is a man of sterling integrity, and an earnest though conservative advocate of labor organization.

The attention of the New York *Sun*, which claims that there is no authority under the constitution for the government engaging in telegraphy, should be directed to the recent establishment of a line between Titusville, Fla., and Jupiter Inlet, over which all vessels passing the lighthouse at the latter point are to be reported. Commercial messages will also be transmitted at the rate of 10 cents for 10 words. Offices will also be equipped at the hotels along the line, provided the proprietors furnish operators at their own expense. The line is in charge of Lieut. B. M. Pursell.

The report of the state commission in favor of substituting electricity for the rope in the execution of the death penalty is rather a doubtful compliment to electricity, and it is questionable whether any lighting company will feel inclined to furnish a current for that purpose. A French mechanic has written Governor Hill from Paris that death by electricity is painful, and submits his device for instantly breaking the spinal column as an improvement over all other methods. A hundred cases per day can be

readily disposed of by this machine, which the inventor describes as "beautiful."

The next meeting of the American Institute of Electrical Engineers will be held on February 14th, when a paper will be read by Dr. Louis Duncan, of Johns Hopkins University, on Alternate Current Motors. This subject has been touched upon in several discussions before the Institute, but this is the first occasion when it has been the leading topic. The interest that has been shown in it leads to the belief that it will be a very important gathering.

The Board of Electrical Control met on Friday, the principal business appearing to be the adoption of such legislation as would force the various electrical companies to remove their poles in streets where conduits are ready for occupancy. It is generally believed that the accommodations in the man-holes are by no means equal to the conduit capacity, and that considerable difficulty will be experienced in making connections after a limited number of cables have been drawn in. This would lead to a rush for first choice but for the fact that some of the companies believe that by waiting until the man-holes are full they will have a legitimate excuse for not going underground.

Commissioner Gibbens does not confine his tilts with Mayor Hewitt to subway matters, but has sent a letter to the papers severely criticising his honor's advocacy of the "single tax" doctrine. The mayor's reply, through the medium of an interviewer, was that Mr. Gibbens was a young man, and had much to learn.

In July last George Addy, a retired blacksmith, of Paterson, N. J., after repeated but ineffectual remonstrances against the planting of a telephone pole in front of his premises, cut it down and severed the wires, among them being one of the fire alarm circuits. Complaints were made against him by the city authorities, and two indictments were found against him by the grand jury. The case came up for trial before Judge Nixon and a jury on January 16th, and resulted in a verdict of not guilty. The remaining indictment is for destroying the property of the telephone company, and is yet to be tried.

There appears to be a conspiracy on foot to force the watch-carrying public either to sell, give away or exchange their cherished timepieces and invest in something which is non-magnetic. In fact magnetism is assuming the same role in watch-repairing circles that has long been maintained by malaria in medical practice. A newspaper paragraph gives as a definition for malaria: "A huge blanket let down over the surface of the earth, under which physicians hide their ignorance." The old fiction of a "broken main-spring" is now discarded, and when your watch is returned to the man who is supposed to have cleaned it with the statement that it loses five minutes a day and that it don't mind its helm, he looks wise and says it has been magnetized. Then for a fee which will buy a couple of Waterburys, he will send it round to a man who has a Maxim machine, which will remove the stagnant juice, and the watch owner will be happier, yet poorer. Waltham has come to the front with a non-magnetic watch, and Benedict's south window is well filled with them. A C & C motor stands in the centre, with a dozen or more horse-shoe magnets of various sizes with watches laid upon the poles and ticking vigorously. All of this is for the purpose of proving that magnetism has no effect on watches of this character. There is a continually increasing army of small boys who will gladly absorb all discarded watches if the opportunity is offered to secure them at nominal prices.

The formal opening of the new house of the Electric Club is to take place Tuesday evening, January 31. The occasion promises to be most enjoyable and interesting. Professor Rowland, of Johns Hopkins University, will make an address. It is needless to say that a large and jovial assemblage will be found at 17 East 22d street, next Tuesday evening.

NEW YORK, Jan. 24, 1888.

PHILADELPHIA.

The Philadelphia Bell Telephone Co. Obtains an Underground Franchise.—Ordinances Granting Privileges to the Keystone and the Edison Electric Light Companies Favorably Reported. —Bids for Public Electric Lighting.

THE Bell telephone underground ordinance passed select councils by a nearly unanimous vote, a few days ago. The obstructionists to the bill tried very hard to defeat it by loading it down with various amendments, but it finally went through with flying colors.

While the Bell people have not been making quite as much noise as some of the other corporations seeking underground privileges, they, nevertheless, seem to have "got there" all the same, way ahead of the rest of them. It is probable that superintendent Gill and Mr. George Snyder brought their eloquence and persuasive powers to bear to accomplish this gratifying result. An ordinary councilman could not hope to withstand their combined assault.

Before the passage of the ordinance, Mr. Bardsley said, if it was the intention to burden the bill with amendments it would fail. If they wanted the wires underground they must legislate in good faith.

Another member said that it was not a question of burying the wires. The Bell Telephone Co. wanted to extend their privileges and increase their business. When a monopoly with its stock far above par, asked to extend its privileges the city ought to be compensated. He offered an amendment, charging for the privileges a species of rental amounting to three per cent. of the company's gross receipts. The privileges to become null and void and the bond to be forfeited in case of default. (This member does not seem to be overburdened with modesty.)

Mr. Fow remarked that he thought commercial enterprises should be fostered, and made a strong point of the fact that the Supreme Court had decided that a municipality had no right to attach any condition to a grant. Mr. Scott said a special act authorized such conditions in grants to telegraph companies. Mr. Fow said the Bell was not a telegraph company. They had the privilege of running the wires all over the country. They did not want to extend their privileges, but to get their wires underground, out of the way of the public in general and the firemen in particular, and they ought not to be caught by the throat. (Sensible man.)

After further discussion, pro and con, Mr. Bardsley referred to the experience of councils with the steam-heat and power company as a case in which the courts had decided against councils' power to attach conditions to their grants, but said that soon after that decision some pipes exploded in New York, and the project of having such a corporation in this city exploded with them. He added that some of the companies were mere stock jobbing concerns, and contrasted with them the solid character of the Bell Telephone Co.

Both the Keystone and Edison Electric Light companies have been favored by a sub-committee of the electrical committee of councils. The Keystone ordinance, as submitted to the committee, provided for a district bounded by Sansom and Arch, and extending from river to river.

Mr. Rudderow, being the representative of the Keystone company, said if the privileges they asked were granted, that is from river to river, between Arch and Walnut, they would light the City Hall, in addition to the other city property they had promised to light, gratis. "We want," said he, "to get to the Schuylkill so that we can erect our plant."

Mr. Wagner wanted to know if they would light the city lamps at 35 cents each.

Mr. Rudderow replied that it would not pay them at that price unless they could get to the Schuylkill.

Mr. Graham urged a proviso binding the company to light all municipal buildings but the City Hall, free of cost. His proviso and amendment were both approved, and in that shape the Keystone bill was at last ordered to be reported favorably.

As the Penn company had already put down conduits, which the Edison will use in a number of streets, the names of such streets were stricken from the Edison ordinance, which was then ordered to be favorably reported with the same proviso that had been attached to the Keystone ordinance as to their obligation to light in return for their privileges all public buildings but the City Hall.

Director Wagner has refused to award contracts for electric lighting at the figures bid by the companies in the Electric Trust, and will send the bids to councils for their consideration. The following are the bids referred to :—

United States Electric Light Co.—North from north side of Market to south side of Poplar street, and east from the west side of Broad street to the Delaware river, 50 cents.

Brush Electric Light Co.—South side of Market to the north side of Spruce, from river to river, 47½ cents; south side of Spruce to the north side of Washington avenue, 50 cents; below and including south side of Washington avenue, 54 cents; west side of Schuylkill, 50 cents; north side of Market and west of Broad, to south side of Callowhill, 47½ cents.

Philadelphia Electric Light Co.—West from the east side of Broad street and north from the south side of Callowhill, 47½ cents; west from the south side of Callowhill, between Eighth and Broad, 49½ cents; north from the south side of Callowhill, between Eighth and Sixth, 52½ cents.

Keystone Light and Power Co.—Between Arch and Walnut streets, from river to river, 35 cents.

Northern Electric Light Co.—North of, including Poplar, and east of, including Thirteenth, 49 cents.

Germantown Electric Light Co.—All territory in Germantown, 55 cents.

Frankford Electric Light Co.—Twenty-third ward and front of Twenty-fifth ward, 55 cents.

Wissahickon Electric Light Co.—All territory in Manayunk, 55 cents.

The specifications required that the lights shall be electric arc lights of at least 2,000 c. p., and they must burn nightly from sunset to sunrise. Lights burning less than eight hours in any one night will not be paid for. No lights beyond the registered capacity of the dynamo shall be attached to the wire furnishing the city lights. The failure of the lights for two nights shall be sufficient cause for the annulment of the contract.

Director Wagner said his idea in having the whole subject referred to councils, was, because after considering the bid of the Keystone Electric Light Co., which offers to light the central part of the city at the rate of 35 cents per lamp, which would make a difference of nearly $100 a day as compared with the price asked by other bidders. My idea is to refer all the bids to councils, and in the meantime to ask these gentlemen to continue to light the lamps on the basis of the rates mentioned in the bids. Two of these bids are very peculiar. The specifications call for arc lights of 2,000 c. p. Two of the companies in the rural districts say that they cannot furnish lights of that power, and that no company in the city has done so.

The director said he did not think there was in the city a light of 2,000 c. p., as required by contract. Chief Walker explained that while the nominal power of the lights was 2,000 candles it was really only 915—a statement which was all the more interesting as the companies had said that the reason why lights could be supplied much more cheaply in small cities than in Philadelphia was because they were not required to be of only 1,200 c. p.

"The president of the Germantown company," the director stated, "said that his company furnished a 1,200 power light, and that that was as good as any light furnished in the city. It is the suggestion of the mayor that this whole matter be carried over for 90 days, until councils have had an opportunity to act on the matter. Our purpose is to ask the companies to go on lighting the lamps; if they refuse, we will go on lighting with gas. There is another matter to be considered. There is an ordinance which gives the Department of Public Works the right to erect poles for electric lighting in the central part of the city, but there is no inclination of the department in that direction. That would probably enable us to get the light at a lower figure, but I doubt whether the result would justify us in encumbering the streets with more poles."

A gentleman largely interested in electric lighting, in speaking of the comparison made in regard to the cheapness of illuminating inland towns throughout the state, as compared with the high price charged in Philadelphia, said:

"Any one at all familiar with the arc lighting business understands that such lighting cannot be furnished for less than 50 cents an arc light, as expenses now go."

"In considering this subject you must remember that the relations are different between the companies and the various cities. For instance, in the inland towns quoted by the councilmanic authority on electric lighting other conditions prevail.

"Here we light the streets every night all the time between twilight and sunlight. In the towns and cities in which such low rates are quoted in comparison with ours you will find that they do not attempt to light the streets on moonlight nights.

"Then besides there is a difference in the candle-power of the light furnished. The interior towns receive a light of a power of 1,200 candles; here patrons are given just twice as much. A most important factor, too, is the amount of capital invested. These old companies I speak of were the first in the field and had to spend a great deal of money. The territory was very extended and the business had yet to be sounded. For the men who originated this enterprise there was the greatest amount of risk and considerable loss.

"In the other towns spoken of less capital is needed and smaller plants are required. These with the other advantages I have mentioned, such as shorter time for lighting and a practical monopoly of the privileges of the town, make it easy for the companies having the town franchises to make money.

"The fact remains to be told that the pioneer companies in the electric lighting field in the large cities have never until now begun to pay the stockholders any return for the money which they originally invested. The Brush company, as you remember, lighted the streets in the central portion of the city for a whole year and all for nothing. I am quite positive, continued the gentleman, "that lower prices will rule as soon as the business justifies it."

There was a lively scene the other day in chief Walker's office over councilman Scott's motion with reference to the ordinance of the Brush and Maxim electric light companies. The sub-committee on the electrical department held a meeting to report upon the matter. Councilman Scott wants to repeal so much of the ordinances of these two companies as applies to privileges for the laying of underground wires. Mr Thomas Dolan, president of the Brush company, said Mr. Scott knew nothing whatever of the subject. President Walker hoped that Mr. Scott's ordinance would not pass, as after January, 1886, no overhead wires could be put up except for public lighting.

Mr. Dolan said that after five years of experiment the company had failed to find any system which would work for long distances, and referred to the fact that in Europe there was no underground system of wires.

He also alluded to several explosions that had occurred at the Brush company's building through experiments with underground wires, and asked the chief if there was not an explosion anly a day or so ago on Broad street, below Fairmount avenue, in the city's underground plant.

Chief Walker—Yes, that's so.

Mr. Dolan asked if there was not danger from gas wherever an arc light was formed, and the chief said there was, and also asserted that the bed of the city streets was saturated with gas.

The discussion ended with the sub-committee deciding to report negatively upon both ordinances.

President Dolan denied the report that the Brush had doubled its stock instead of declaring dividend. The Brush company had expended $400,000 and the Maxim $300,000 in experiments with underground wires.

In reference to the story that during last spring, when the Penn, the Edison and the Keystone companies were fighting for privileges in city councils, the Keystone company employed Pinkerton detectives to shadow the city councilmen, Mr. Rudderow says: "I deny that the employment of detectives had any reference to members of councils. We wanted to know what the Penn people were doing, as the information was of value to us. What the company did in employing detectives to investigate the Penn Electric Light Co., was nothing to be ashamed of. It was entirely a business measure and how anybody could imagine that it bore any relation to any councilman, I fail to understand. The detective work was our private business, and had nothing whatever to do with councils."

PHILADELPHIA, Jan. 15, 1888.

BOSTON.

Electricity Discussed at the Merchants' Club Dinner.—Another Trial of an Electric Car by the West En l Co.—Underground Telegraph and Telephone Wires.—Report of the Underground Wire Committee of the Board of Aldermen.—The Cambridge Electric Light Co.—Use of Electric Lamps under Water.—Electricity in Horse-Training.—The Western Union Company Sued for State Taxes.—Special Provisions by the Signal Service for Announcing the Approach of Snow Storms.—Annual Output of the American Bell Telephone Co.—Dinner given to Superintendents and Managers by the Officers of the New England Telephone Co.

PRESIDENT Richard Briggs was at the head of the table at Parker's, crowded around which sat seventy-five gentlemen, members and guests of the Merchants' Club, last evening. Among these guests were Professor C. R. Cross, of the Massachusetts Institute of Technology, Dr. C. J. Blake, Professor W. W. Jacques, President H. M. Whitney of the West End Street Railway Co., Colonel G. H. Benton, Jr., Rev. Stopford Brooke, C. A. Coffin, and Mr. E. H. Johnson, President of the Edison Electric Light Co.

After dinner the president introduced Professor Cross, who said that all we know of electricity was the phenomena in which it played a part and the effect which it produced. Electricity is apparently not ordinary matter; it does not have the property of inertia, which is the fundamental characteristic of matter. Neither is it a form of energy. It is an existent something which is apparently not ordinary matter, and it is certainly not energy. The mere fact that we cannot define it except by negation does not prevent our measuring it, perhaps more accurately than we can measure anything else. We can also separate it into parts. The possibilities of transmitting speech electrically depends upon the production, by means of the sound waves, of electrical changes, variations which shall be wavelike in their nature.

Professor Johnson said that the telephone had been in existence ten years. Last year it had been used to transmit 600,000,000 messages. On an average every man, woman and child spoke into the telephone each once a month. He thought the most important use of electricity was the transmission of sound. The invention in the telephone was a conception by which electric waves could be carried with very great rapidity and perfect accuracy to very great distances and there reconverted into sound waves.

Mr. Whitney, who was introduced as a merchant, said—

The work which my associates and I have undertaken in reference to the transportation facilities of this city we believe is for the benefit of this community. This does not relate to the subject of electricity, I admit. Electricity, however, is a subject to which we have given quite a good deal of attention. I remember very well discussing the question of electromotive power and of cables with my friend Mr. Richards. He said to me, "Mr. Whitney, why do you want to talk to me of hell? Take away horses from our streets and you put us into hell." The few experiments that we have tried with electricity have not been successful. I was in hopes that my friend, Mr. Johnson, here, would explain the reason why. It is not that electric motors are not a success. It is true that the electric motors that we have tried here have not been a success; but that, I believe, is simply incidental. But the great difficulty attending the use of electricity on a street car is the difficulty of finding a proper storage battery. I apprehend there is no difficulty whatever in getting, sooner or later—and very soon—a proper motor which shall do the work. There have been very grave doubts whether any tractive power could be used in the streets when there were snow and ice. Some of the experiments that have been made in this city this year lead me to believe that it is possible to do so. Experiments which have been made in other cities seem to me to demonstrate its

practicability. Mr. Johnson tells me that even now there are discoveries which make it seem entirely practicable that the problem of the storage battery will be solved. I certainly hope it is so, for I hope the time is near at hand when something is coming to take the place of horses.

Mr. Johnson was asked if Mr. Edison could help them out in this matter, and replied that the electric motor could surely be applied to street railways. "The only question is as to the methods for conducting the electricity from the power station to the car. I am confident that you will soon see your cars run with electricity supplied by the electric motor.

Dr. Clarence J. Blake gave an interesting account of his early experiments with Professor Bell, and Professor Jacques said that within ten years the number of telephones had increased from one to 350,000, and long-distance telephoning was possible. Colonel J. H. Benton, Jr., and others spoke, and the club adjourned.

The West End Railway Co. has been for some time engaged in experiments in connection with electric cars, and to-day a trial trip was made with the Weston car, which has already made several trips. The car came in from Cambridge by way of East Cambridge, the inventor, Mr. William L. Stevens, and others, being aboard. On arriving at Post Office square the car was met by a few gentlemen who had been invited to witness the test, and ran through Federal, Franklin, Washington and Milk streets, back to the square. The car then ran to Causeway street and returned by way of Canal and Sudbury streets, continuing through Tremont and Boylston streets to Columbus avenue, where the speed was increased to ten miles an hour for a short distance. While running on a level the car moved smoothly, and there appeared to be no difficulty in going around sharp curves; but on steep grades there was not sufficient traction and the wheels would frequently slip.

The Western Union Telegraph Co. laid, about two years ago, two tubes containing wires through State, Washington and Friend streets to the Eastern station on Causeway street. These are the only underground wires used by the company in Boston.

About five miles of underground conduits are used by the New England Telephone & Telegraph Co., the number of ducts in the conduits varying from two to twelve. Each duct has, under the present system, 200 wires; but with the metallic circuits which are being introduced, only 75 wires can be held in each duct. One conduit now goes from the central station, at the corner of Pearl and Franklin streets, through Pearl, Congress, State and Exchange streets to Dock square; here it divides, one conduit going through Union, Endicott and Beverley streets to Warren bridge, while a spur line runs through Brattle, Court and Cambridge streets to Staniford street. There is a conduit from the central station up Franklin street to Washington, and a spur line runs through Arch and Chauncy streets, Harrison avenue, Beach, La Grange and Tremont streets to Ruggles street. There is also a conduit from the South End office to the Back Bay.

The joint committee on underground wires made a report at a meeting of the aldermen, December 19th last, the concluding portion of which is as follows :—

"The fact is now admitted in all the large American cities that the wires must ultimately be placed underground. The principal obstacles to the system have been done away with, and the main objection of the companies has practically reduced itself now to one of expense only. The cost of establishing the present overhead wire system has been excessive, and this expense will be practically a loss to the companies when the system is abandoned and the wires are placed underground. While it is also true that the first cost of placing the wires underground will be large, the cost of repairs and maintenance will, according to the testimony of experts, be much less than is required in the present overhead system. Your committee believe it would be unwise to compel the electric wire companies operating in Boston to place their wires underground in separate conduits, and that the city must either construct a subway for the reception of all electrical conductors, or contract with some conduit company to construct underground conduits of sufficient capacity to receive all surface wires in operation."

Mayor Whipple, of Brockton, Mass., on retiring from office, alluded to electric lighting.

"One of the most important improvements that have been made is the introduction of the Edison municipal system of street lighting, all naphtha and gas lights having been replaced by electric lights. By the adoption of this new system we are enabled to turn on the light in any section of the city at a moment's warning, in case of fire or any other emergency; and aside from the advantages gained, the introduction of the system adds much to the general appearance of the streets."

The Cambridge Electric Light Co. is replacing its present street lamps with those of the American system, and it is expected that the new lights will be ready for use next week.

An electric light was recently used to find a body under water, near Boston. It was first demonstrated by the United States government that the electric light could be used to good advantage in the deep. The government uses it effectively in the capture of fish, and the steamer Albatross, in the service of the Fishery Commission, is provided with a full equipment of lights to use for that purpose. The lights are incandescent, but the glass is much heavier than that used in lighting rooms. It is encased in a wire netting, which acts as a guard and prevents breakage. The net also acts as a trap. The light is connected with the dynamos with specially constructed cables. The fish, being attracted by the light, swarm into the net, which is then closed and pulled in. The specimens not wanted by the commission or the steward are restored alive to their natural element. The light can also be used in the recovery of dead bodies from wrecks, and is destined to be an invaluable aid to divers. It is said that some Gloucester fishermen contemplate using the light in their business.

A spirited horse that has a disagreeable way of bolting was made the subject of an interesting experiment recently at the veterinary school of Harvard University. Dr. Harrison of the school procured a battery, of small size, and extended two slight wires from it along the reins to the bit of a bridle. These wires terminated in small knobs. Then the electricity was applied to the horse, care being taken to use it in connection with the words "whoa" and "steady." The animal after a few experiments became docile, and his "bolting" ceased. He was tried under circumstances calculated to excite him, and the experiment proved perfectly satisfactory. The experiment is one of considerable importance, since, though it has been tried in France, it has not been performed in this country before.

Suits have been begun by the attorney-general against the Western Union Telegraph Co. to recover the state taxes for 1886 and 1887, amounting to $11,416.26 and $15,085.38. The allegations in these cases are substantially the same as in that now pending in the United States courts for the taxes of 1885, the details of which have been already published.

The signal service is making arrangements for giving warning of the approach of heavy snow storms sufficiently in advance to enable railway officials to make arrangements that will prevent delay to travel. These predictions, which it will be the aim of the signal service to furnish as early as thirty-two hours before the storm, will enable railway superintendents to expedite the movement of freight trains and to side-track those that it is evident cannot be brought to their destination. Observers are instructed to enter into communication with railway officials in their districts, and ascertain whether they desire these warnings by telegraph from Washington. Those who adopt this means will receive the warnings as soon as the local observers. Messages will be sent by telegraph to certain selected stations, and immediately upon their receipt observers will make every effort to inform the public through the press and by bulletins posted in conspicuous places of the approaching storm. Any person in the vicinity of a signal station who signifies his willingness to pay the cost of telephoning or telegraphing will be furnished these reports as soon as they are received from Washington.

The statement of output of telephones by the American Bell company for the month ended Dec. 20 herewith is given, together with a tabulation by months of the outputs for the fiscal year, and a comparison of the year's total with that of 1886:

December—	1887.	1886.	
Gross output	3,486	3,946	Dec. 460
Instruments returned	2,094	1,686	Inc. 408
Net output	1,392	2,260	Inc. 868

FISCAL YEAR ENDED DEC. 20.

	Gross output	Instruments returned	Net output
January	3,974	1,956	2,018
February	3,405	1,918	1,487
March	4,372	1,452	2.920
April	4,685	1,870	2.815
May	5,256	2,320	2,936
June	6,971	1,598	5.373
July	4,345	3,196	1,149
August	3,533	3,353	180
September	4,110	2,152	1,958
October	3,689	2,213	1,476
November	4,330	2,667	1,663
December	3,486	2,094	1,392
Year	52,156	26,789	25,367

YEAR'S OUTFIT COMPARED.

	1887.	1886.	Increase.
Gross output	52,156	42,306	9,850
Instruments returned	26,789	19.924	6.865
Net output	25,367	22,382	2,985

A good example for officers of electric companies may be noted in the dinner given on Dec. 21st by the management of the New England Telephone and Telegraph Co. to their division superintendents and managers of exchanges, at Young's hotel, in this town. About forty plates were laid. Previous to dining a conference was held, when the best methods of managing the offices and general business were discussed.

BOSTON, Mass., Jan. 16, 1888.

WASHINGTON.

Government Telegraphs in Congress; Various Schemes Proposed.—A Bill for the Relief of War Telegraph Operators.—Efforts to Introduce Electric Light in Government Buildings.—Electric Light Notes.—The Chesapeake and Potomac Telephone Co.—

Underground Cables.—President Green of the Western Union Telegraph Co. and Hon. Gardiner G. Hubbard give their Views on Postal Telegraphy, before the Senate Post-Office Committee.

THE opening session of the Fiftieth Congress brings back as fresh as the day they were introdued the long list of bills to transfer, in one way or another, the control of the telegraphing of the country from private hands to the general government.

Senator Edmunds was the first in the field with his old bill, to construct four trunk lines from Washington, to be extended from time to time as appropriations therefor may be made by Congress. The general control of the construction is placed in the hands of the engineer corps of the army, while the working and operation of the lines, as a part of the postal system of the United States, is put under the charge and direction of the Postmaster-General. Clerks, electricians and operators are to pass a civil service examination. Two million dollars are appropriated outright to initiate the undertaking.

The seventh section of the bill is so peculiar that it is given entire below:

"*Section* 7. That the Secretary of War is hereby authorized and directed, with the approval of the President of the United States, to construct or take and use all such machinery, appliances, devices and materials, not including telegraph lines owned by persons or corporations, whether patented or not, as shall be deemed necessary for the convenient and successful establishment and operation of said lines; and in case said secretary cannot, with said approval of the President, agree upon the value of such property, or any part thereof, or of any right or interest therein, the owner or owners of such property, or any right or interest therein, shall be entitled to file a petition for just compensation therefor in the Court of Claims of the United States, which court is hereby invested with jurisdiction to hear, try and determine the same, subject to an appeal to the Supreme Court of the United States; and the sums of money necessary to pay any such final judgments of said courts, respectively, are hereby appropriated out of any money in the treasury not otherwise appropriated; but no refusal of the owner, or any person or corporation claiming any right in any such property, to receive such compensation as may be offered by the Secretary of War, with the approval of the President, shall have the effect to prevent, hinder or delay the taking and use of any such property for the purposes aforesaid."

Senator Cullum's bill proposes to establish a postal telegraph on a rather more elaborate basis, and starts out with a four million appropriation and the same indefinite amount to pay the awards of the Court of Claims. He proposes ten trunk lines, viz: Washington to Portland, Me., Washington to Minneapolis, Minn. and Washington to Galveston, Texas; New York to Cleveland, Ohio, Pittsburgh to Topeka, Kan., Toledo, O., to Detroit, Mich., Chicago, Ill, to New Orleans, La., Chicago to St. Louis, Mo., Chicago to San Francisco, Cal., and from Chyenne, Wyoming, to Denver, Col. Stations are to be located at all first, second and third-class post-offices *en route*. The same provisions for construction and control are provided as in the Edmunds bill, except this bill provides a "Director-General of Telegraphs," with the rank and pay of an Assistant Postmaster-General. It also proposes the poles shall be of iron, of size and strength to carry twelve wires. Between Washington, New York and Chicago eight wires, and on the other routes four wires are fixed as the initial number. The rates for the transmission of messages are also fixed at ten cents for twenty words or less, and five cents for each additional ten words or fraction thereof when the distance is less than five hundred miles, and five cents additional for each two hundred and fifty miles or fraction thereof. Press rates are fixed at 75 cents per hundred if sent during the day, and 35 cents per hundred if sent during the night. Drop copies 50 cents for day and 25 cents for night. Manifolding five cents per hundred words. Why this discrimination is made against the press will probably come out in the course of debate. This bill goes further than that of Senator Edmunds, and applies the civil service rules to those employed in receiving, transmission and delivery of telegrams.

The House of Representatives, being a new body, consumed some time in getting ready for business, and it was not till the 4th of January that an opportunity was afforded for the introduction of bills.

Mr. Rogers, of Arkansas, led the telegraph reformers with his bill of the forty-eighth Congress, which in that Congress got so far as to be reported from the Post-Office Committee to the House. This bill fixes the rates between New York and Philadelphia, Baltimore, Boston and Washington, and such other points separated by short distances as may from time to time be designated by the Postmaster-General, at 15 cents for 20 words. Under 2,500 miles, 25 cents and five cents for each additional 250 miles. No rates to exceed 50 cents. Night service, half price, except when the 15 cent service prevails—which is not reduced. Press matter 75 cents per hundred for day and 35 cents for night transmission. This bill contains one very proper clause, viz.: "Telegrams shall be privileged communications in law to the extent that sealed letters now are." The money order system is made applicable to this postal telegraph.

Having thus created a postal telegraph system he proposes after advertising for proposals to contract with the telegraph company making the lowest bid for the performance of the service as provided in the bill.

Mr. Weaver, of Iowa, takes a more comprehensive view of the subject. He ignores the feeble efforts that have been made by private capital to establish telegraphic communication, and proposes to connect by such a number of postal telegraph wires as will meet the requirements of the people for business and personal correspondence "All the post-offices of the country south of the northwest boundary of Washington Territory, having a population of four hundred (400) inhabitants." And the Postmaster-General is authorized to connect such other minor post-offices as he may deem proper, the object of the bill being to ultimately and as speedily as practicable reach every post-office in the country.

The rates are made uniform at 10 cents for 10 words, and five cents for each additional 10 words. Press not exceeding 20 cents per hundred.

An appropriation of $25,000,000 is proposed as a *starter*.

Mr. Anderson, of Kansas, comes back with his bill of the last Congress, proposing three trunk lines, with numerous branches, as follows: Bangor, Me., *via* Boston, Albany, Buffalo, Cleveland, Toledo, Chicago and Madison, Wis. New York *via* Philadelphia, Pittsburgh, Columbus, O., Indianapolis, St. Louis, Kansas City to Salina, Kansas. Baltimore *via* Washington, Richmond, Raleigh, Augusta, Atlanta, Montgomery, Mobile, New Orleans, Houston, Austin to San Antonio, Texas. It is proposed to connect with all land grant lines on the terms embraced in such grant, and such other lines as may have or shall hereafter accept the terms of the act of July 24, 1866.

The Postmaster-General may construct air or underground lines by contract or may through the Secretary of War require the work to be done by the signal corps.

The rates in this bill are fixed at 30 cents for 10 words and three for each additional word, but the Postmaster-General may reduce the rates where there are competing lines. Ten millions are appropriated out of the treasury to start this scheme.

Mr. Raynor, of Maryland, proposes by his bill to create an inter-state telegraph commission of three members, to be appointed by the President, with a salary of $5,000 each per annum, to lay out, build and construct trunk lines of postal telegraph with power to control rates for the transmission of despatches—and appropriates eight millions for the carrying out of the plan proposed.

Mr. McComas, of Maryland, proposes a more novel scheme. He proposes that after July 1, 1888, telegraphic messages may be deposited at any place in the United States where letters are deposited, prepaid in postage stamps. Meantime the Postmaster-General shall advertise for facilities for the transmission of despatches and if the aids of existing corporations are not satisfactory the Postmaster-General may advertise for proposals to construct the necessary lines. The rates fixed for the transmission are one cent a word, counting date, address and signature—with a deduction to the press of 40 per cent. above 100, and under 500, and 50 per cent. on all over 500 words, or postal wires may be leased to newspapers. Whenever telegrams are left at post-offices where there is no telegraph they are to be forwarded to the nearest postal telegraph office.

Mr. Warner, of Mo., has reintroduced the Logan bill for the relief of telegraph operators during the war (H. R., 1,607). It provides for a certificate of honorable discharge on application to the Secretary of War, and the same rights of homestead entry and pensions as are now or may be allowed by law to others who served in the army. It also provides that appropriate medals shall be struck and presented to those who served as operators and builders in the war. With the medal clause, which will invite opposition, stricken out, the bill which has been modified to meet the views of the war department ought not to meet with any serious opposition.

Repeated attempts have been made to introduce electric lighting into the national capitol, but up to the present time they have proved unsuccessful. At the beginning of the Forty-seventh Congress the American Electric Light Co. obtained permission to put in at their own expense an experimental plant to light the restaurant, some of the halls and some of the rooms with their incandescent lights. The exhibit was quite creditable, but they failed to secure an appropriation for an extension of their work or to repay them for their outlay, and the effort was abandoned.

Two years ago the Edison people attempted, by an elaborate effort made on the same terms, to convince the Senate of the superiority of the electric light, and succeded so far as to get a clause in an appropriation bill to pay for the plant then in, and for its material extension, but the House struck it out, and in conference the clause was framed in such ambiguous language that no one would take the responsibility of acting upon it, and neither was the money paid nor the order for the extension given. Disgusted with their experience, the parties interested, after an expenditure as I am informed, of over $6,000, have withdrawn their plant.

At the House end the United States companies, parent and local, essayed to give a more desirable light, and put their lamps in the cloak rooms, and a few elsewhere. Owing to some mis-

understanding, growing out of the divided responsibility, their exhibit was not as satisfactory as it could and should have been, and they failed to secure recognition, for which, however, no strenuous exertion was made.

Undaunted by the fate of their predecessors, the Sawyer-Man company this year obtained permission to introduce their system on similar terms—*i. e.*, the work to be done without expense to the government or damage to the building, and early in November commenced wiring both wings of the capitol. They have arranged their wires for a very large number of lights in the cloak rooms, halls, restaurant, folding-rooms, offices and committee rooms; put in an engine and dynamo for each wing, and put up their wires in a most thorough and permanent manner, as if they intended to stay I have no data as to the expense to which they have gone, but it is many times in excess of any former effort in this direction. If they fail, their failure will be sufficient to deter others from undertaking so hazardous an enterprise. The work will be finished and the lights started early in February.

The United States Electric Light Co. (local) having secured the control of the Edison incandescent system for the District of Columbia has established an extensive central plant at the corner of 13½ and B streets, and are putting in eleven engines with a combined power of 1,400 h. p., sufficient, it is estimated, for 10,000 incandescent and 500 arc lights. They now light the principal business streets with their arc system (Thomson-Houston) and are constantly extending their light to the minor streets.

Their incandescent lamps have, since the plant was started, taken the place of the arc when used in business places, and have been substituted for the Weston high tension lamps, formerly used in the treasury department. A thousand lamps have just been put in the bureau of printing and engraving, and the entire state, war and navy department building is being wired for the introduction of the Edison lamp. The Western Union office has also been wired, and the lamps are to be started in a few days. Orders have been given for numerous other public and private establishments, and are being filled as rapidly as possible.

This company has been at much expense in laying cables underground, having tried a number of different manufacturers, and in every case where they have attempted to use a high tension current the cables have failed. Repeated efforts to take up and repair have also failed, and those cables are now abandoned. Still they are laying new cables for their incandescent lights, under the belief that a lower tension will not destroy them. Incidental to their lighting system, the company proposes to furnish motors to the various mechanical industries in their immediate neighborhood to be used during the day when the power is not needed for lighting purposes. It is believed this can be done to the profit of the company and the manufacturers.

The Chesapeake and Potomac Telephone Co., which embraces this city and Baltimore, have been more successful in the use of cables, although they find the retardation of the current somewhat annoying. They extend their cables from the central office through the central part of the city and thence by air lines to subscribers. They have adopted the plan of using two cable wires for each air line, grounding the return wire where it leaves the cable. The effect of this it is claimed destroys the induction and makes the circuit approximately a metallic one.

This company has just declared its usual quarterly dividend of 1¼ per cent., and laid aside a handsome sum for construction account. It is now putting up a new office in Baltimore, corner St. Paul street and Bank lane, to be six stories high, strictly fireproof, and costing, with the ground, $120,000. It will be ready for occupancy about midsummer. So satisfactory has the cable service been here that they will, during the coming season, expend a large sum in that direction in Baltimore, where it is proposed to lay from 6,000 to 8,000 miles of wire underground.

A question as to the rights of these underground cables has arisen here, the solution of which will be of interest. Under a permit, or rather a *mandate* of the commissioners, this company, some time since laid their cables under the sidewalk, alongside the curb, on 15th street, including the frontage of the National Safe Deposit Co. Subsequently the Deposit company obtained a permit to build a vault under the sidewalk. During the excavation the wires were temporarily stayed up as best could be, but when the flagging was to be laid the removal of the wires was demanded and their forcible displacement threatened. The telephone people prayed out a temporary injunction, and the matter is now before the court for a final adjudication.

The National Board of Trade, at its recent session in this city, adopted by a vote of 26 to 9 a resolution, "That the usefulness of the post-office department should be extended in the direction of telegraphic communication; and we urge upon Congress the earliest favorable consideration of this question." The telegraph appears to be getting along very well in private hands just now, and the necessities of the public reasonably well met at lower rates of charges than ever before, while the coal traffic is a good deal disturbed. Perhaps these gentlemen could see a way for the government to assume control of the coal mines, and give to all their fuel at a minimum charge—say $3 or $4 per ton. Then in the progressive spirit of the postal telegraph schemes, they could take the iron furnaces, which are so intimately connected with the coal productions, and so go on with the iron and steel interests until our watch-springs and needles bore the stamp "U. S.," and every woman in the country was guaranteed a needle that would not cut in the eye or snap at the point. What a glorious day it will be when a paternal government gives employment to everybody and furnishes everything they want at prime cost!

Messrs. Norvin Green and Gardiner G. Hubbard have been before the Senate post-office committee and given their views upon the postal telegraph, reports of which have been given by the daily papers. The older members of the committee were indisposed to give them a further hearing, as their tales had been thrice told, but, like the girl who got married because the children had never seen a wedding, they consented to a hearing out of consideration for the new members.

WASHINGTON, Jan. 19, 1888.

CHICAGO.

Successful Starting of the City Electric Light Plant on the Water Front.—Apparent Cessation of Hostilities against the Gas Trust.—The St. Louis Gas Trust.—The Brush Light Station at St. Louis Damaged by Fire.—Unexpected and Unaccountable Gas.—Incandescent Light Competition at Chattanooga, Tenn.—Mr. C. H. Wilson as Superintendent of the Chicago Telephone Co.—Corporation Counsel Green's Opinion on Telephone Licenses.—Resolution of Counsel to Refuse Further Permits to the Telephone Company.—Mr. J. E. Zeublin Succeeds Mr. C. H. Wilson in the Central Union Telephone Co.—Another Indiana Court Decision Adverse to the Central Union Telephone Co.—The Chicago Electric Club.

THE river plant, which is the name given to the electric light plant owned and operated by the city for lighting the Chicago river and the bridge approaches. was successfully started on the 24th of December, with only 12 lights. Since that date the number of lights in operation each night has been gradually increased, until now there are lighted each night 30 lights extending from Polk street to the lake on the south side of the river. The effect of the light exceeded even the expectations of Professor Barrett and Mayor Roche, who were the original promoters of the scheme. The river is lighted so well as to render navigation as feasible at night as during the day, and it is intended to give the vessels practically free way up and down the river from 12 midnight to six in the morning, thus lessening the obstruction to navigation of the river, and at the same time keep the bridges closed for street traffic during the day. Mayor Roche has recommended to the council that the system be extended by the installation of a 125 light plant at the west side pumping station.

Judging from the votes which have been taken in the city council lately on matters relating to the Gas Trust it would seem that war had ceased for some reason. No action has been taken so far in the matter of the *quo warranto* proceedings which attorney-general Hunt was instructed to bring.

Another plan for defending the city against the alleged extortions of the Gas Trust has been proposed by alderman Clarke. His plan is for the city to purchase an incandescent electric light plant and substitute a 32 c. p. incandescent electric lamp for each gas burner now used on the streets. This scheme is ably presented by alderman Clarke, whose connection with the Edison company puts him in possession of useful facts and figures for his purpose.

The Gas Trust, of St. Louis, is undergoing an investigation at the hands of the city council, which succeeds in bringing to light many interesting facts regarding the methods of the Trust. The Laclede Gas Co. is the only one of the companies doing business in St. Louis, which has not joined the Gas Trust of that city. This fact and the further fact that the Laclede company has practically decided to go into the business of electric lighting may have had something to do with the decline of over 40 per cent in the market value of Gas Trust certificates.

The station of the Brush Electric Association, of St. Louis, was damaged by fire on the 6th of this month. The damaged machinery was promptly replaced, and the business of furnishing lights was continued with little interruption.

Much interest and discussion has been aroused by an unexpected flow of gas from a water pipe leading from the lake into a brewery in the southern part of the city. Many believe it to be natural gas, but analysis shows it to be very different from the natural gas of Ohio and Pennsylvania. However, it has continued to burn steadily for several weeks now, and preparations are being made on a limited scale to make use of it. This discovery has led to considerable prospecting and seems also to have been the means of bringing to notice the fact that the artesian well in the Leland hotel furnishes a copious supply of gas as well as water. At least one other gas producing well has been found within the city; and it is claimed that large flowing wells have been found within piping distance. The development of the incandescent gas burners gathers interest in connection with the discovery of natural gas, and with the prospective franchise of a fuel gas concern which proposes to manufacture fuel gas in the Illinois coal region, at a cost of one cent per thousand feet, and pipe it to Chicago. It is

exciting particular interest in the minds of the stockholders of the Chicago Edison company, whose plant is proceeding slowly to completion.

At Chattanooga, Tenn., two incandescent electric light systems are contending for supremacy, and the contest has unusual interest because it is between alternating and continuous current systems. The Hauss continuous current system has now some 2,500 lights in operation. The Westinghouse has about 650—the entire capacity of the dynamo which is now in operation.

Mr. C. H. Wilson, the recently appointed superintendent of the Chicago Telephone Co., assumed the responsibility of his new position, January 1st. His experience with the single cord system of multiple switch-board at Columbus has been so satisfactory that he will probably decide on the introduction of a similar system in Chicago. He has changed the location of the operating room in the new telephone building from the third to the top floor and proposes to go further than was originally intended, in the direction of consolidating the business, and transfer to the new office the business now done in three exchanges.

Judge Green, corporation counsel, has submitted an opinion on the question whether under the ordinance now pending before the council the city has the right to license telephones. The ordinance now pending, it will be remembered, is the one instructing the Commissioner of Public Works to refuse permits, which are necessary for laying wires, until the telephone company should produce a receipt, signed by the city collector for the sum of $10 for each telephone in use in Chicago. Judge Green's opinion is that the power to license is inhibited by the fact that the occupation is not directly or impliedly enumerated in the general incorporation law, and that it is not within the boundaries of the police power, and that it does not come within the spirit or letter of the law authorizing the exercise of that power for the protection of the lives or health of the citizens, or the preservation of good order and public morals. He is therefore of opinion that the ordinance is illegal. But he claims that unless the telephone company has the explicit consent of the city to operate its lines upon or under the streets, such occupancy of the streets could not be valid, in view of the strict provision of the statutes requiring the consent of the city for that purpose.

This opinion of Judge Green, together with his recently submitted opinion to the effect that the franchise under which the company is now operating is invalid, has made conspicuous the weak point in the position of the telephone company. That the council were not slow to adopt the suggestion embodied in the opinion is shown by the following resolution, adopted at the same meeting at which the opinion was read :

Resolved, That the Commissioner of Public Works is hereby directed and instructed to issue no further permits to the Chicago Telephone Co. to use the streets and alleys of the city of Chicago for telephone purposes until the further order of the council.

Mr. J. E. Zeublin, recently and until the consolidation of the Baltimore and Ohio Telegraph Co. with the Western Union Telegraph Co., general superintendent of the former company, succeeds Mr. C. H. Wilson as superintendent of the Ohio division of the Central Union Telegraph Co.

A recent decision of Judge Ventor, at Lafayette, Ind., adds one more defeat to the long list which the Central Union Telegraph Co. has suffered in that state. Judge Ventor holds that under the well-known Indiana statute, relating to telephone rental rates, a company doing business in that state is bound to furnish every applicant with a telephone and connections at the statutory rate. The telephone company set up in its answer, a demurrer to which is sustained by Judge Ventor's decision, that it was not engaged in the business of renting telephones or of supplying private wires or private telephones to anyone; that the only form in which it undertook to serve the public was by means of what is known as the public toll system, under which the company established agencies or public stations at the residences or business houses of all persons to whom it supplied telephone service, and that all such persons were the company's agents, and that all individuals on equal terms might, by paying five cents for each connection, use these telephones at such stations. The court held that while the company might perhaps legally conduct business in this way, yet, as it was engaged in a general telephone business, it was, nevertheless, bound to supply every applicant for telephone connections and facilities at his residence or place of business with a telephone, and the necessary apparatus and facilities for placing him in connection with all the local patrons of the company, at $3 per month, the statutory rate.

The Chicago Electric Club gave a very enjoyable entertainment and lunch on the evening of January 7th. The members were enthusiastic in their praise of the arrangements made by the entertainment committee, of which Mr. H. Ward Leonard is chairman. The entertainment consisted of a musical programme with an intermission for lunch, and it was a very agreeable departure from the usual formal banquet. At the regular meeting, held on the 16th, Mr. C. A. Brown read a paper on "Our Patent System and its Proposed Amendment."

CHICAGO, Jan. 19, 1888.

SAN FRANCISCO.

A Visit to the East.—Chicago Street Cars.—Admirable Organization of the Western Union Service in Chicago, under Col. Clowry.—Personal Changes in Western Union Service in California. Electric Light in the San Francisco Prison.—Affairs of the Postal Telegraph Co.

YOUR correspondent has been absent from this coast for a considerable period, during which he has journeyed and sojourned in the east; at least east as far as Chicago.

The City of Chicago presents a fine field for an electric railway and yet there is none. The street car system is ante-deluvian and abominable. Their cable system is away behind, and inferior to ours, and their horse cars make walking a luxury. It is true, that Lethes pool (the Chicago river) is a drawback to good cable systems, but should be none to electric roads. And yet in other respects Chicago leads the world: As far as the Western Union management is concerned, it certainly does—Col. Clowry has surrounded himself with a staff the like of which is not in the length and breadth of this great continent. Messrs. Summers, Bristol, Tubbs, Lloyd (and the minor staff under Lloyd) make labor a pleasure. The writer desires to record the fact that in his quarter of a century of experience, the past six months in Chicago has been made the pleasantest he has spent in a telegraph office (and he was no exception to the general treatment of operators). Mr. Lloyd is very able and energetic, with the finest disposition and equanimity of temper and clear judgment. During the writer's stay in Chicago, Col. Clowry and Messrs. Summers and Bristol were on this Pacific Coast overhauling things in general, and infusing new life into the management of San Francisco and other places in California. John McRobie was taken from the Board of Trade office in Chicago and made manager of San Francisco, with full control. Geo. D. Thomson, night chief operator of Chicago, was made chief operator of Los Angeles. Mr. McRobie's appointment was a God-send to San Francisco. The cry of down-trodden and outraged operators was heard and answered. He will have a herculean task to evolve order out of chaos, and chaos at best it was—but, if any man can do it, McRobie is equal to the task.

Col. Clowry seems to have appreciated the fact that Mr. Jaynes was over-worked and that the rapid growth of his division diverted his attention from minor details and local necessities, hence, he ordered F. H. Lamb from Portland to San Francisco to act as assistant superintendent to Mr. Jaynes.

Gen. John McComb, late editor of *The Alta-California* and now warden of San Quentin prison, appreciates the necessity of illuminating the outer and inner yards of the prison by electric lights; establishing a plant solely for the prison, to be operated by prisoners (there are a few *electricians* and *operators* there). How would it be in the event of a revolt if the electricians were in league with the Jack Cades? The idea is a bright one.

The Postal company are still struggling and wrestling with local Northern business; no move having been made to build or extend their lines in any other direction. It is just a year ago since in this correspondence the advisability was pointed out of building south and east. Assurance was given by Mr. Henry Rosener, a director—that they would, within a few months, begin such construction—and yet they have not, nor do they evince any intention to do so, thus giving a corroboration to the rumor that Mr. John W. Mackay has no longer any financial interest in the Pacific Postal Telegraph Co.

His superintendent was discharged and a Canadian put in Robeson's place. This would look as if the Canadians were running it. It is to their interest to have it known that Mr. Mackay is still connected with that company, because two-thirds of their business is secured through Mr. Mackay's popularity, when every circumstance points to exclusive Canadian Pacific control. If it is once authenticated in this city the toleration and forbearance of the public will cease and business necessity will supplant personal friendship, and the Postal will lose by the confirmation of the rumor.

SAN FRANCISCO, January 17, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

THE REIS TELEPHONE CONTROVERSY.

[85.]—The experiments with the old and original instruments of Philip Reis were made by me, in this country, during the summers of 1885 and 1886, and the first account of them appeared in

the *Scientific American* for Nov. 28th, 1885; later on, by correspondence with Professor Edwin J. Houston, they were published in *The Journal of the Franklin Institute* for January, 1887, and July, 1886. In this correspondence I have fully stated the nature and results of my work, and, taken together with the published records of my testimony in the Overland Telephone cases, they furnish all the information necessary for any who may care to review the subject. I refer to them simply at this time to answer certain charges made by Dr. Stein in your issue of July, 1887, one of which is that I misstated in my testimony on Oct. 15th, 1885, when quoting from the *Industrie-Zeitung*, by leaving out certain important words, viz.: "It was impossible, with the apparatus as then constructed, to transmit spoken words." Any one who will take the pains to read the context will plainly see that the question which I was then and there required to answer had reference solely to *musical quality*, and not to *articulate speech*. The quotation was properly and rightfully restricted to such parts as referred to "*quality*"; further on, in the same answer, I quote from the annual report of the Physical Society of Frankfort-a-M., 1860–61, a paragraph in reference to articulate speech, where *quality* enters in as an explanation given by Reis himself why his instruments reproduced "the consonants pretty distinctly, but the vowels as yet not in an equal degree." (Amer. Bell. Tel. Co. *vs.* Overland Tel. Co. of N. J., vol. 1, Defend's ans. and proofs, page 704, interrog. 4.) The more serious charge that I changed the apparatus itself, so as to cause it to conform to later telephone inventions, can have for its basis no foundation whatever in the minds of those who read the testimony from an unprejudiced standpoint, the so-called fundamental change being "*the loosening of a binding post*, which had pressed the contacts of the transmitter too tightly! The simple facts are that the metallic strip which supports one of the contacts had become bent where the binding post passed through it, and, in consequence, the contacts were pressed together so as to form *a tight joint*, and *no variation of the electric current whatever was possible* until the pressure at the joint was relieved; this was done by loosening the binding post a little. I maintain that the mode of operation of the instrument was not thereby changed to conform to more modern inventions; on the contrary, the disposition of the contact points was *then* such that "breaks" would naturally occur for all the *principal* vibrations of the membrane—a condition which was insisted on by counsel as the original disposition of the parts by Reis himself; and that "breaks" *did* occur, approximately equal in number to the principal vibrations, was evident in my experiments by the humming sound of the electrodes, as they broke contact, and the succession of electric sparks (*The Journal of the Franklin Institute*, July, 1886, page 59). I do not ask the privilege of your columns to indulge in any personal controversy, as I might be justified in doing from the nature of the charges made; but I prefer to leave the experiments open, as they always have been, to the scientific public, to verify by practical tests—which, in my own estimation, would be a far better proof of the verity of my statements than any written argument possibly can be.

The other points in the controversy, referring to myself, have been fully answered by Professor Houston, and I need not refer to them here.

The investigations of Mr. Kintner have been of especial interest to me, as pointing to a conclusion which I myself reached from practical experience with telephones of many kinds, viz.: "that articulate speech, sufficiently good for commercial purposes, can be produced by *makes* and *breaks* in an electric current, if properly timed as to their duration," etc. In one of my published letters in 1886, I state that it is my belief that articulate speech can be thus transmitted, when such breaks are timed and spaced by the voice itself. I shall look with additional interest for the demonstration of this principle, which Mr. Kintner promises to furnish in his admirable articles upon the subject now appearing in THE ELECTRICAL ENGINEER.

So far as the Reis instruments are concerned, I am inclined to agree with Professor Dolbear to this extent—that the transmitter is an automatic device, and is subject to the intention of the operator only to a limited extent. As regards the receiver, my own experience confirms Professor Dolbear's statements that speech has and can be transmitted and received by a Reis transmitter and Reis receiver in the same circuit. It cannot be disputed that, in any magneto-receiver, articulate speech is perfectly reproduced by *the iron core, and its helix of surrounding wire* (saying nothing of the diaphragm). Such a receiver is the Reis knitting-needle receiver, pure and simple; and it reproduces, faithfully and accurately, whatever variations in the electric current are produced at the transmitter. Granted that the Reis transmitter transmits a single word, that word must of necessity be reproduced by the Reis receiver; theoretically it is easy enough to see this, and the fact is self-evident without demonstration; but the courts require a demonstration which shall convince the most obdurate by the sense of hearing alone; and the volume of sound given out by a Reis receiver being very small indeed, there will be those in almost every public trial who will say they could not hear it.

Starting with a potential of at least five or six volts, and giving the electric current at transmitter as wide a range of variation as possible, the receiver has, in my own hands, spoken loud enough to be heard by any one. The real difficulty here lies, as we all know, in effecting a wide range of variation in resistance with platinum alone. It is comparatively easy with a few grains of carbon, and *even lead peroxide*, to do this, as I have shown in a paper reported in the London *Electrical Review* for Nov. 11th; but in the case before us we are limited to platinum, and hence great skill and care have to be exercised. JNO. R. PADDOCK.

Stevens Institute of Technology, Dec. 12, 1887.

ELECTRO-MAGNETIC SEPARATORS.

[86.]—Since the publication of my second article on the "Uses of Electricity in Mills" in the December issue, page 487, in which reference was made to the greater strength of electro-magnets as adapting them for more efficient use than permanent magnets in applications where magnets are employed to separate bits of iron from the stock in various processes of manufacture, I have learned that electro-magnets charged by a small Mather dynamo especially constructed for the purpose have been used with especial success over the permanent magnets formerly used in separating iron from the stock in process of paper manufacture.

C. J. H. WOODBURY.

Boston, Mass., Dec. 22, 1887.

LIMITATION OF UNITED STATES PATENTS BY FOREIGN PATENTS.

[87.]—In the U. S. patent law limiting the term of a patent taken out in the U. S. by the expiration of the foreign patent, this reading occurs (Rev. Stat. 4887):

"But every patent granted for an invention which has been previously patented in a foreign country, shall be so limited as to expire at the same time as the foreign patent."

The courts have decided in a large number of cases that the American patent must expire coincidently with the foreign one. As it is well known that the most important American patents on the incandescent light have expired under this law, have not the patents of the Bell Telephone Co. become null and void, by the decision of the Commissioner of Patents, of Canada, who declared the Bell patents void in Canada some months ago for failure to comply with the law?

I. H. DAVIS,
Dorchester, Mass.

January 10, 1888.

[The Canadian telephone patent was issued *later* than the U. S. patent. The duration of a United States patent is limited by the *expiration* of the *term* for which an *earlier* foreign patent has been issued. The *voidance* of a foreign patent has no effect upon the period of an U. S. patent. As stated by our correspondent, the Canadian Bell Telephone patent was voided—it did not expire.—ED.'S ELECTRICAL ENGINEER.]

LITERATURE.

REVIEWS.

Management of Accumulators and Private Electric Light Installations: A Practical Hand-book. By SIR DAVID SALOMONS, BART., M. A., A. I. C. E., M. S. T. E. Third edition, revised and enlarged. London: Whittaker & Co., and New York: D. Van Nostrand.

Sir David Salomons evidently does not approve the too common practice of grinding out successive editions from old "plates," just because they are handy. The present edition is even more radically improved, as compared with the second, than was the latter as compared with the first. In fact, the author has practically made an entirely new book, much better, both in scope and in substance. He has wisely concluded to cut a deeper furrow through this new fertile soil, and in order to do so, he has enlarged the title and the compass of the book, which has grown from 31 to no fewer than 146 pages.

The work is divided into two parts, as the title would of itself indicate. Each part has, moreover, been sub-divided into chapters, and some 28 illustrations have been introduced in the text, in addition to the frontispiece, illustrating the interior of Sir David Salomon's own accumulator house at Broomhill, his country seat. These features make the work far more comprehensive, convenient and clear than was the case with the previous editions.

Considering the very general attention which the applications of electrical storage are now attracting and also the lamentable meagreness of the literature of the subject, a practical work like this one, setting forth the teachings of experience—the things of all things most desirable—will undoubtedly be well received by the majority of electricians, to whom it will be very useful, if not indeed quite indispensable.

It is probably not asserting too much to say that there is no

person more competent than Sir David Salomons to write on the subject of the handling and management of accumulators, for it is doubtful if anybody could be found whose experience in this field is so comprehensive. He has done most valuable missionary work in studying what are sometimes called the vagaries and idiosyncrasies of the storage battery, his efforts dating from 1882, when the first storage batteries were placed upon the market, until the present day. Sir David was, it is true, well qualified for this work by combining, as he does in a happy manner, those four requisites—the leisure, the means, the facilities, the ability—which are so highly important in dealing with matters involving research and experiment. The last chapter of his work recounts, in an interesting manner, the transformations made in his own installation at Broomhill since 1882.

The $10,000, which he admits his futile experiments alone to have cost him, doubtless cover many severe disappointments; but it is encouraging to learn that these experiments have not been in vain, since they have enabled him to find remedies for many, if not quite all, the troubles which formerly beset the storage battery. It is, to say the least, a highly favorable sign of a good future for the storage battery to find Sir David's faith in it remain unshaken by his experience.

In expressing our opinion that Sir David Salomons is much more adept in the practice of ferreting out facts than in the art of recording or classifying them, we do not wish to detract in the least from the value of his highly meritorious work, but to imply rather that the author has not utilized to the highest advantage the rich stock of material which his experiments and observations have furnished him. The present edition, as did those preceding, suffers from numerous inaccuracies of diction and little grammatical faults, which suggest that a little careful editing would have been of great benefit. Moreover, the author does not seem to have found, in every instance, that happy way of stating facts which makes their implication quite clear to the reader. For instance, on page 62 he confuses electromotive force with difference of potential in the following sentence: "When the plates are sulphated, the internal resistance of the cells is greater, and the E. M. F., for daily use, is much lower." The same error is again made on page 111, in the statement that when a shunt-wound dynamo is short-circuited at its terminals, "practically no E. M. F. exists, and no current passes." On page 82 the author assumes the "friction load" of an engine to be constant, whereas it is in reality only approximately so, as engineers well understand. These, and a few other errors that appear in the book, should be carefully weeded out in succeeding editions. It is to be hoped that the author will cover yet more ground in the next edition. There are many topics which he has left untouched, and which really would be well entitled to a chapter each. Sir David Salomons has doubtless enough information to give us a "practical treatise" instead of a hand-book next time, and it is greatly to be hoped that he may do so.

Elementary Text-Book of Physics, by PROFESSOR WM. A. ANTHONY and PROFESSOR C. F. BRACKETT. New York: John Wiley & Sons, 1887.

Seven chapters of this work, embracing 130 pages, are devoted to electricity and magnetism under the following heads, viz.: I. Magnetism. II. Electricity in Equilibrium. III. The Electrical Current. IV. Chemical Relations of the Current. V. Magnetic Relations of the Current. VI. Thermo-electric Relations of the Current. VII. Luminous Effects of the Current. As might be expected from the limited space devoted to such extensive subjects, the treatment of magnetic and electric phenomena is brief and imperfect. The theoretical side of the subject-matter alone is considered, and the text consists mainly of definitions and resultant formulæ which appear to be anything but elementary. While this portion of the book may serve a useful purpose in the way of suggesting to teachers a course of study which may be advantageously enlarged upon, to the average student or practical worker it can have but little value, since there are already other works which cover the same ground in a simpler and more thorough manner.

RECENT PUBLICATIONS.

Bouant, Emile. La Galvanoplastie La Nickelage, La Dorures L'Argenture et L'Electrometallurge. Avec 34 figures. 16mo., 303 pp. Paris: Libraire *J. B. Baillière et Fils*, 1887.

Fortschritte der Elektrotechnik. Viertel jährliche Berichte über die Neueren Erscheinungen auf dem Gesammtgebiete der angewandten Elektricitätslehre mit Einschluss des Electrischen Nachrichten und signalwesens. Unter Mitwirkung von Dr. M. Kiliani und Dr. E. Pirani, herausgegeben von Dr. Karl Strecker. Erster Jahrgang, 1887, Erstes und Zweites Heft. 8vo. 396 pp. illustr. Berlin: Verlag von Julius Springer, 1888.

Fourth Report of the Board of Commissioners of Electrical Subways of the City of Brooklyn. 8vo., 12 pp. December, 1887.

Kempe, H. R. A Hand-book of Electrical Testing. Fourth edition, revised and enlarged. Crown 8vo. 550 pp. with 159 diagrams. $5.00. New York: *E. & F. N. Spon.*

Management of Accumulators and Private Electric Light Installations. A practical hand book, by Sir David Salomons, Bart., M. A., A. I. C. E., M. S. T. E. Third ed. revised and enlarged. London: *Whittaker & Co.* New York: *D. Van Nostrand*, 1888.

Michaut, Aug. L'Électricité, Notions et Applications Usuelles. 12mo., 410 pp. Paris: *Georges Cairé*, 1888.

Mourlon, M. Charles; Secrétaire Rapport. Sur les Travaux de la Société belge des Electriciens, pendant l'exercice, 1886–87. 4°. 12 pp. *Bruxelles*, 1887.

Ninth Annual Meeting of the National Telephone Exchange Association at Pittsburgh, September 26 and 27, 1887, 8vo. 120 pp. Brooklyn, 1887.

Report on Underground Wires, by a Committee of Common Council, City of Boston. 8vo. 12 pp. December, 1887.

Transactions of the American Institute of Electrical Engineers, vol. iv. Meetings of June 8th and December 7th, 1876; February 6th, March 15th, May 18th, and June 28th, 1887. 8vo. 232 pp., illustr. New York city: Published by the *Institute* at the office of the Secretary. 16 Dey street.

CATALOGUES AND PAMPHLETS RECEIVED.

The "C & C" Electric Motor Co. have issued a pamphlet that is not only useful but extremely dainty. It is entitled "Some Cuts of "C & C" Motors and Apparatus." The cuts are uncommonly handsome, and exhibit motors, batteries and several useful applications of the motors. There is just text enough—and no more—to indicate and identify the objects shown; rather a good feature in circulars of this kind, which commonly contain more letter-press than busy people will read. The illustrations in the "C & C" circular are so fine and clear as to furnish all the description needed.

The Electric Water Protective Co., 713 Broadway, New York, send us a small pamphlet setting forth their readiness to furnish electric protection against water overflows. Their apparatus acts automatically to shut off the flow of water before damage is done. The utility and desirableness of such a protection are very obvious, and will no doubt be fully appreciated by owners of large buildings, as well as ordinary householders.

ELECTRICAL NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF JANUARY 10, 1888.

The President, Mr. T. Commerford Martin, took the chair, and said—The subject before us this evening is of a very interesting nature. The paper is by Mr. Willard E. Case, of Auburn, N. Y., and is entitled "Electric Energy from Carbon without Heat." In the absence of Mr. Case, Mr. Mailloux will read the paper.

(Mr. C. O. Mailloux then read Mr. Case's paper. See page 50.)

Mr. Mailloux—Mr. Case also favored us by sending a sample of the battery, which you have here. (Referring to a battery which stood upon the table.) It consists of a porous cup in which the graphite, in lumps, is placed, and outside of which is a sheet of platinum. Sulphuric acid, of the greatest density obtainable, chemically pure, is placed in both the inner and outer vessel. As explained in the paper, in order to render the sulphuric acid active, Mr. Case puts chlorate of potassium into the outer vessel, which gives it a light wine color. I have brought a little galvanoscope, which I have calibrated for the purpose, so that it gives a rough indication of the voltage of the battery. Each division represents $\frac{8}{10}$ of a volt; and when I close the circuit, you will see that it gives a deflection which is about 14 degrees. That would be equivalent to about $\frac{7}{10}$ of a volt. I think that Mr. Case states that the electromotive force of his battery is between $\frac{7}{10}$ and $\frac{8}{10}$ of a volt; but unfortunately, as you notice, the electromotive force falls very rapidly, owing to polarization. You will notice it is now falling. It is now only 12 degrees. It seems to stay there better. But if I let it rest a little while, it comes to more nearly the full strength, though not quite.

The President—You have heard this very interesting paper read. It is now open for discussion, and it seems a subject fertile enough to elicit a very full treatment on this occasion.

DISCUSSION.

Mr. Mailloux—I might state for the information of the members, that Mr. Case states, in a note sent with the battery, that the internal resistance is about $2\frac{7}{10}$ ohms, and that when placed on short circuit it gives, approximately, a quarter of an ampere for a short time. He adds, by way of explanation: "You understand I am not showing a practical invention; simply showing a new principle, which may be developed." I think you will all agree that undoubtedly there is here a wonderfully interesting principle.

A Member—Will you please give us the calculated electromotive force?

Mr. Mailloux—The calculated electromotive force of this form of cell is not given. Mr. Case simply states the observed electromotive force, which is $\frac{8}{10}$ of a volt. The calculations that he made, which I put on the blackboard, were merely the efficiency of the combination, of which heat was the active element. He gives the energy of combination—yes. Carbon and oxygen combined to form carbonic acid, so that the carbon is completely oxidized, give 9,624 foot-pounds per grain equivalent, or 2.0924 equi-volts. You will observe that that is our friend Sprague's nomenclature, which will have to be further elucidated in order to be intelligible. As I am not a disciple of Mr. Sprague, I would like to have somebody else explain it.

Mr. T. Wolcott—I would like to ask why the cell polarizes so quickly. As I understand, the oxidizing liquid is in contact with the platinum. It ought to act, I should think, like the chromic acid in a Poggendorff cell, to oxidize the hydrogen; or is it hydrogen that polarizes it?

Mr. Mailloux—Mr. Case states that the polarization can be prevented by mechanical means; so that it is probably due to uncombined chlorine.

Mr. J. Wetzler—I was about to suggest that the polarizing might be brought about by the setting free of the peroxide of chlorine; that is the gas produced, and it is probably the one that causes the polarization.

Mr. F. B. Crocker—About the polarization; it is very evident the active material there is $CL\ O_2$, and that is in solution in the liquid. There the oxygen of that $CL\ O_2$ combines with the carbon and sets free chlorine, and that chlorine is set free on the platinum, and that, of course, polarizes the cell; and I should imagine that Mr. Case's mechanical means for preventing the polarization are just the same as the mechanical means for depolarizing in a cell which polarizes by the liberation of gas on the negative plate, that is, simply shaking it, or roughening the surface, or using a platinized silver plate or anything of that sort, to get rid, more or less, of the gas, and in that way avoid polarization. There is also the formation of $C\ O_2$ (carbonic acid gas) on the positive plate. That also would produce polarization.

Mr. C. S. Bradley—The figures given seem to me hard to understand. (Referring to equations on the blackboard.) The heat units which are given out by the combination of different substances, of course, can be found in many books. In Watt's chemical dictionary, which I have here, will be found the heat of chemical combination and the heat of chemical action. The various energies are given and the number of heat units given out by an atom of the various substances. Now, we find, when we refer to carbon and oxygen, that 12 pounds of carbon uniting with oxygen to form carbonic acid, give out 94,800 heat units.

This will heat 94,800 pounds of water one degree. That is Andrews' determination. Favre and Silberman give 96,960. Now, in the first place it is necessary to reduce everything to a hydrogen basis. We find that there are two atoms of oxygen. This calls for four atoms of hydrogen. Therefore it is necessary to divide 96,960 by 4, giving 24,240. Now, the volt is about 23,030. I have tried it both experimentally and by calculation, and that is as near as I have been able to come to it. I presume that is not accurate. That, you see, would give a trifle over a volt. It is, perhaps, $\frac{11}{100}$ over a volt that that carbon is capable of giving theoretically. Now, that of course can be determined experimentally. There is also a way of calculating it from the foot-pounds and the correlation of forces, etc. Now, this is the measure of the chemical pressure—the heat units are the measure of the chemical pressure, and the chemical pressure determines the electrical pressure. You can get but just so many volts out of any combination of two substances, and you can calculate just the possible amount that you can get in volts.

The question of resistance is one of the main points in the whole of this subject. I tried, in 1882, quite a long series of experiments with fused salts and their action upon coal. Of course the oxygen of the atmosphere is absolutely necessary. We cannot by any means expect to accomplish direct conversion unless we use the oxygen of the atmosphere. Otherwise we must use a manufactured product, which must be very expensive. Therefore, we have got to introduce the oxygen of the atmosphere, which is just as essential as the coal. That battery costs a great deal more to run, from the chlorate of potash used, than a zinc battery. So that to get cheap power in that way it is necessary to use carbon or hydrogen, or the combination of those, or the oxygen of the atmosphere; and to use the oxygen of the atmosphere, you must either supply it at the time you are operating with the coal, or from the manufactured article. Manufactured articles are dear; so it is necessary to use it at the time. Therefore, I hit upon the plan of taking manganate of soda or potassium and putting a blast of air through the electrolyte, and by that means supplying it with air and allowing it to act on the coal, which is put into another part of the vessel. The main point is the resistance. The voltage falls very little short of the theoretical. That is all right; but the resistance is too high for it to be practical. At least I have always so regarded it. It would require a surface equal to a pond about ten feet in diameter per horse-power (laughter), that is, if you allow a space of two inches between the coal. Of course, coal is a rough substance. You have got to allow it a considerable distance between your plate on which the oxygen supply is furnished, and it is the coal which runs up the resistance.

Then, in studying up the matter, I saw in Watt's chemical dictionary that F. Braun had a determination of the conductivity of fused salts in the neighborhood of their melting points. Putting the conductivity of mercury equal to zero, he found that of the best sulphuric acid to be about 7,700. The following numbers were also obtained: Chloride of lead, 32,200; nitrate of soda, 11,475, and so on. But of all the records I have ever found, and in all the experiments I have tried, chloride of lead is of the lowest resistance or the highest conductivity among the salts. It is about four times as good as the best sulphuric acid. We noticed in some of the electrical papers of a late date mention of Mr. Acheson's device, in which he proposes to use gases in one case. Now, gases are of a great deal higher resistance than any fused electrolyte, and the fused electrolyte, of course, is, as I said before, too high. The lead chloride is the lowest. It is possible, of course, that somebody may find substances of very low resistance, but it is rather a hard job. Now, of course, I do not mean to advance this as a pessimistic view of the matter at all. It is just simply to make a statement of the conclusions which I have reached, which I hope may be of benefit to others, and perhaps save them some experiments and time.

Mr. Wetzler—The previous speaker, in criticising the apparatus devised by Mr. Acheson, in which gases are used as the medium between the electrodes, has remarked that they are of very high resistance. I think that is a question of relativeness merely. I do not know what the absolute resistance of the fused products which the previous speaker employed is, but we all remember the experiments originally made by Faraday, who, after placing the points of an electric circuit a short distance apart, heated up the terminals of the platinum wires and effected the passage of the current thereby. You also know that if we heat the air sufficiently, as is done in an electric arc, we get comparatively low resistance.

Mr. Bradley—I also made this experiment. I employed an outer vessel of zinc in which was placed a porous cup containing a bar of zinc. The outer vessel was filled with a concentrated solution of zinc chloride, and the porous cup was fed by a constant stream of fresh water to maintain the solution within it dilute. The vessel was then heated by a Bunsen burner from below.

In that way I could control it so as to keep the inner zinc cool, while the outside dish was heated. It is well known that chloride of zinc has a high heat of solution. My idea was, that if I could keep a strong solution in the outer vessel, just on the point of crystallizing, in contact with the zinc, and a weak solution within the porous cup, I could cause a passage of the molecules of zinc across and a current to be generated. The calculated electromotive force from the arrangement was $\frac{8}{10}$ of a volt. I worked at it a good while before I got $\frac{8}{10}$ of a volt, but finally I did get it. The question of resistance, of course, comes in, and that is the greatest difficulty in all apparatus of this kind. On weighing the outer vessel and the interior plate, the latter should have lost and the former should have gained. But I found that the inside one had lost; but it was hard work to find that the exterior one had gained anything. So it left me in doubt whether the $\frac{8}{10}$ volt was actually due to the heat of solution or not. But it is quite interesting as an experiment.

Mr. Crocker—The question of equi-volts is rather an interesting one. I shall not go into the figures, but I think Mr. Sprague, of England, has done the subject a good deal of harm by prefixing that "equi" to the well-known term "volt." People are used to that word, but the result of prefixing "equi" to it has been that people have let it alone, just as if he had attached a dynamite bomb to it. And really I do not see why it is put there. An equi-volt, as far as I can see, is just as much a volt as any other volt. It is well enough, perhaps, to designate volts obtained by chemical action as equi-volts; but I do not know any reason for it. You might just as well separate volts obtained by an Edison dynamo, and call them Edi-volts. Really these equi-volts are just plain, ordinary North American volts. And I think if that were used more—the calculation of the volt of chemical action—it would be of great service in a great many cases. For example, Mr. Bradley and I, before we had made any experiment at all on the subject, calculated out what would be the electromotive force of a combination of zinc and bromine; we calculated just as Mr. Bradley described there, by taking the heat units produced by the combination of zinc and bromine, and then going through those figures we obtained $1\frac{8}{10}$ volts. By a great many experiments, very carefully carried on, we got $1\frac{78}{100}$ volts. Now, that is just $\frac{2}{100}$ different from our calculations. At first we got $1\frac{8}{10}$, because, of course, the instrument would not detect that $\frac{2}{100}$ difference. It was only by continual experiments that we got the average of $1\frac{78}{100}$. Now, that is close enough for all practical purposes, and you can arrive at results which are practically close enough with a combination of zinc and iodine, for example, or any combination of two elements, or an element and a compound body. For instance, you can calculate out the electromotive force of zinc and chromic acid, or nitrate of soda, or any other depolarizer, and you will arrive at results which approximate quite close enough for practical purposes to the actual electromotive force obtained by experiment.

Now, that seems to me to be a very important thing, because very often you want to find out these facts and have not time to try it, and you save yourself the experiment by calculation; and, of course, all kinds of short cuts like that are often quite an advantage to the investigator, and, so far as I know, it is very seldom used. Mr. Sprague is about the only authority who speaks of it at all, and in practice I have never met any one who used that method. Some people doubt that you can get reliable results at all. They claim that they are mere accidental coincidences;

but I think when they occur a great many times and when you can actually prove by the figures that there is such a relation, then there can be no longer any doubt about it.

The contact theory has also prevented the adoption of this calculation of electromotive forces. The idea is that there is a contact difference of potential; that it is not due to the chemical action, but is due to the contact; that chemical action merely makes the action continuous. I never could see much in that contact theory myself. If you have a plain chemical affinity there, and that produces so much energy in the form of heat, for instance, why shouldn't it produce the same amount of energy in the form of electricity in a voltaic cell. The contact theory is one of those things that you cannot see any reason for. Why should zinc and bromine have a contact difference of potential of $1\frac{8}{10}$ volts? Whereas you *can* see a reason why they should have a certain chemical electromotive force. The contact theory is a purely arbitrary thing. A man tells you there is a contact difference of so-and-so. There is no reason for it that I can see, and the fact that the contact difference of potential is usually the same in liquids as in air, is due to the fact that there is oxygen, moisture, etc., present in the experiments, and you have substantially the same conditions that you have when you try them in a voltaic cell.

And those two theories of contact difference of potential and the "equi" prefix to "volt" have retarded a very important branch of science, I think.

Mr. Wolcott—I do not understand why the zinc would be dissolved off from one electrode and deposited on the other. Does the chloride of zinc dissolve the metallic zinc?

Mr. Bradley—The Grotthuss hypothesis is generally understood. There is a chain of molecules of chlorine and zinc all the way across the electrolyte. If there is more affinity for the zinc on one side than there is on the other, the zinc will cross over as soon as the current is closed.

ELECTRIC LIGHTING ON THE BOSTON AND ALBANY R. R.

Among the papers contributed to the International Railroad Congress, at Milan, was one by Mr. G. W. Blodgett, electrical engineer of the Boston & Albany railroad, from which the following data are taken relating to electric lighting by that company.

At East Boston the following points are lighted by electricity: First, the grain elevator, which has six lamps in a single line opposite the scales; 2d, freight-houses Nos. 6, 12 and 13 on the east; and freight-house No. 5, pier No. 1 and the entrance on the west, where ocean steamers load and discharge to the cars; 3d, a wharf where coal from vessels is discharged into cars; 4th, two engine buildings. There are also lamps in the yard near important switches and crossings. All these are Brush lamps of 2,000 nominal c. p. In the buildings they are 14 feet high, the greatest height which the buildings permitted. Out of doors the height is 24 feet. Although there are 48 lamps, only 36 can be operated at the same time. It is sometimes necessary to use a larger number of lights than can be operated by the dynamos. A choice is then made of those most indispensable, and the lighting is completed by gas or oil lamps furnished with reflectors.

Electric light is used only when the number of lamps needed is nearly the capacity of one dynamo; that is to say, 18. When only two or three are needed, gas is used.

The cost of the electric apparatus at East Boston, in place, was as follows: Buildings, $3,116.12; 60 h. p. engine, in place, $1,-737.10; shafting, pulleys, etc., in place, $364.29; belting, $412,30; two Brush No. 7 dynamos, $4,000; 44 lamps, with two sets of carbons, $3,520: two regulators for the dynamos, $250; wires, insulators, telegraph poles and cross-arms, and labor in setting up the machinery, lamps and wires, $1,322.75; total, $14,722.56. The boilers used for the elevator engine also supply steam for this, and the cost of boilers or boiler-house is therefore omitted. The cost of operation during the year ending Sept. 30th, 1886, was $2,277.34, or $7.28 per day, or 20 cents per lamp per day, assuming 36 are used. This includes fuel, but not cost of boilers or boiler-house. The lamps are used irregularly. When a vessel is at the wharf they are usually burned the whole night until the loading has been completed, when they are, perhaps, not used again until another vessel arrives, if it be delayed, unless the elevator is to run at night, or cars are to be unloaded. Two men are employed to run the engine and dynamos during the night and replace the carbons during the day. They work as many hours as is necessary—sometimes 20 hours or more in the day, when the lamps burn all night, and sometimes only four or five hours. The average is about 10 hours. When the electric lamps are not used, these men are employed in other work.

At Boston the passenger station, train house and yard are lighted by 33 arc and 12 incandescent lamps. There are two Brush dynamos of 16 lamps each, and as they are run at a speed of 825 turns per minute, 18 lamps can be used. They are placed at a height of 12 feet, except five, which are 24 feet high. Four men are employed; two renew carbons and make repairs during the day. Two others work at night: one for the boilers and engine, and another who operates the dynamos and patrols the circuits. The lamps have double carbons and can burn all night. They are lighted at dusk, and run until after the arrival or departure of the last train.

The cost of the apparatus, not including engine or boilers (which are in use by the repair shops), was as follows: Two Brush dynamos, $4,000; 33 double arc lamps, $2,640; 2 single arc lamps, $120; 2 automatic regulators for dynamos, $250; wires, insulators, fixtures, etc., and work of setting up, not including main shafting, etc., $1,206.47; total, $8,216.47. The cost of operation for the year ending Sept. 30th, 1886, was $6,-465 11, or $184.72 per lamp per year, or 50.6 cents per lamp per day. The cost per lamp hour was about six cents. The cost of power furnished is $2.50 per day, besides the wages of the engineer. Carbons cost 80 cents; oil waste, etc., about three cents per day. The cost of repairs to five Brush machines during six and one-half years has not been more than $150. Neither a lamp or dynamo has yet been replaced or sent to the factory for repairs. All such have been made by the men in charge. These installations were the first by a railroad company in New England, if not in America, and are still the most extensive. At Worcester the passenger station is well lighted by 20 arc lamps, placed 15 feet high in waiting rooms, and 24 feet in the train house. The cost is about twice as much as formerly paid for gas (which was never satisfactory), but several times the light is obtained. The cost is 70 cents per lamp per night. It costs about the same at Springfield. At Pittsfield the electric light company light the passenger station for the same price formerly paid for gas, about $1,400 per year.—*Railroad Gazette.*

DOMESTIC ILLUMINATION BY ACCUMULATORS.

The ball-room of Mr. Ogden Mills' residence, 69th street and Fifth avenue, was lighted by means of the N. Y. Isolated Accumulator Co.'s storage batteries on Monday night, 16th Jan. The occasion was a ball and house warming, and a large assemblage of the leading members of New York society were present. The ball-room was brilliantly illuminated by sixty 16 c. p. lamps—the electricity being supplied from the batteries which had been charged on the previous Friday at the Electrical Accumulator company's factory, Newark, N. J.; carted to Mr. Mills' residence on Saturday; placed in position in the cellar and connected with the lamps on Monday, and used from 9.30 P. M. until 3.30 A. M. the following morning without a single interruption of any kind.

The effect of the lights was very beautiful, and many expressions of admiration were heard on all sides.

Mr. Cornelius Vanderbilt afterward ordered sufficient storage batteries to illuminate his Fifth avenue mansion on the occasion of his grand ball given on the 23d Jan.

This is the first instance in which storage batteries have been used in America to furnish temporary light for special social occasions, and its success is likely to lead to a large business of this character in all prominent cities.

A DYNAMO WITH INTERNAL POLES.

Some time ago Messrs. Siemens & Halske, of this town, brought out a new type of dynamo with internal field magnets, which was described and illustrated in *Industries*, vol. iii., p. 45. A similar machine was also brought out by Messrs. Ganz & Co., of Buda-Pesth; but priority for the invention has been claimed by two other firms, viz., Messrs. C. & E. Fein, and the Helios Company, of Cologne, both of whom lodged protests at the Patent Office when Messrs. Siemens & Halske applied for a patent. From a recent decision of the Patentamt it appears that the protesting parties have been successful, and the following reasons are given for the refusal to grant the patent: "There have been prior publications, notably Patent No. 13,802, figures 12 and 13, covering the principle of internal magnets placed radially, and the manner of supporting the external armature laterally has also been anticipated in Patent No. 13,158, figure 2. Although these designs have previously been chiefly used for alternate current machines, it cannot be contended, with the present general knowledge of dynamo electricity, that the application of the design to continuous current machines is a patentable novelty. Moreover, such application has already been forestalled in Patent No. 19,265, figures 15 to 18." This decision will show how very strict the Patentamt is in dealing with inventions for which patents would be granted in England as a matter of course.—*Industries.*

THE TELEPHONE FIGHT AT ROCHESTER, N. Y.

A VICTORY FOR THE TELEPHONE COMPANY.

The subscribers to the Bell Telephone company's service whose contracts extended beyond Nov. 17, 1886, the date of Rochester's great telephone strike, are all interested in the test suit that was tried before Justice Rumsey, in the Circuit Court this week. The point at issue was whether the company could collect rents for instruments after the strike became general, and the subscribers whose contracts had not run out alleged that the service was

worth nothing to them, owing to the fact that so few people used the telephones as to reduce the number in active operation from 1,200 to about 200. This assertion was made by many of the strikers, notwithstanding that they themselves were refusing to answer the calls of their instruments as well as to send messages by them. Justice Rumsey to-day decided the point in favor of the Bell company, refusing to allow its suit against George H. Worrall & Co., to recover for back rent to go to the jury, but ordered a judgment of $66.87 for the company, which includes interest.

The amount of money involved in the suit is small, but as the suit was tried as a test case the issue is of the greatest importance. In directing a verdict Judge Rumsey said the contract into which the telephone company and the defendants had entered was decidedly one-sided, but with that feature of it he had nothing to do. Under that contract there was no guarantee that the number of subscribers would be increased or would not be diminished, or, in fact, kept up at all. It did not guarantee that the company would continue in business in the future except to complete its contracts. The company had just as full a right to close up its business as a grocer after completing its contracts. There was no evidence to show that the change from the flat rate to the toll system or that the prices under the toll plan were exorbitant or unreasonable. The only restriction in the most extreme view of the case that would be imposed on the company was that it could not willfully make such rates and conditions as would cause the public to be excluded from the right to use the system. Such an act must be of a willful character and for the purpose of exclusion. If the company raised the rates and if it were a mere error of judgment to the best means of conducting business that would be a mere mistake and would not constitute a willful act which could be restricted.—New York *World*, January 25.

ELECTRICITY AND THE LAW.

One of the new questions arising from the application of electricity for all the modern purposes in which it is now used, has been that of its relation to ponderable matter in the rights of property. There have been several instances in America where electricity has been diverted from leads of central stations by persons not subscribers, but abstracting it for their own use. Some time ago, we noted an account of the summary manner with which the proprietors of an incandescent light station in New York city treated the thieves of electricity, by sending for about a second over the line as heavy a current as the system would stand, thus ruining most of the apparatus of the thieves, and producing very mysterious electric phenomena, which formed the subject of a very learned paper read before one of the electrical societies. At Lowell, U. S., another man recently made connections with the wires for a telephone station not only for his own benefit, but also for that of some of his associates, with whom he had a central "station." The legal questions in the matter were of such a nature as to perplex even the very astute counsel of the telephone company. But there has recently appeared another problem in the matter. There is an electric light station in the town of St. Stevens, in the Province of New Brunswick, the conductors of which lead over the St. John's river to Calais, U. S., and the collector of customs on the part of the United States, vigilantly watchful of its position in the enforcement of a protective tariff, immediately sent to the secretary of the treasury of the United States to ascertain what would be the duty on electricity, and it has finally been decided by the official head that electricity is not dutiable, being an invisible and subtle agent of power, possessing no substance as a merchantable commodity. The question as to whether the bees who

"Gather honey all the day,
From ev'ry opening flower,"

in Mexico, and then flew to their hives in Texas, did not commit smuggling, or, at least, were dutiable in themselves, was not considered a clear precedent in the above ruling of the secretary of the treasury.—*Engineering* (London).

TELEPHONE PATENTS IN MEXICO.

The Supreme Court of Mexico, by decision published January 19th, has sustained the validity of the Bell and Blake patents, which in this country are held by the Mexican Telephone Co. The suit did not arise from any question as to the claims of Bell and Blake, but grew out of an action for infringement of patent brought by the telephone company against parties who had sold instruments not supplied by the company. Defendants took the ground that although patents had been granted to the telephone company by consent of Bell and Blake, the former was not legally entitled to hold them, as the laws of Mexico require that patents should be issued to actual inventors and that assignments should be made afterwards. This suit has been followed with much interest, and to-day's decision, which confirms the title of the Mexican Telephone Co., is considered of great importance. —New York *World*.

OBITUARY.

Balfour Stewart.

Professor Balfour Stewart, M.A., LL.D., F. R. S., died on Monday, December 19, at Ballymagarvey, Ireland, having just completed his 59th year. He was educated at the Universities of St. Andrews and Edinburgh. In 1859, he was appointed to the directorship of the Kew Observatory, and in 1867, to the secretaryship of the Meteorological Committee, which last appointment he resigned on his promotion to the Professor's chair of Natural Philosophy in Owen's College, Manchester, in the year 1870, a position which he held until his death. Two years before this distinction was conferred upon him he had been awarded the Rumford medal by the Royal Society for his discovery of the law of equality between the absorptive and radiative powers of bodies. Together with Messrs. De la Rue and Loewy, he wrote "Researches on Solar Physics," and he and Professor Tait published their researches on "Heating produced by Rotation in Vacuo." Besides these he wrote a number of treatises especially on the subjects of meteorology and magnetism. The article in the *Encyclopædia Britannica*, on "Terrestrial Magnetism" is from Professor Balfour Stewart's pen. Among the many works of which he was sole or joint author may be mentioned the "Elementary Treatise on Heat," "Lessons in Elementary Physics" (1871), "Physics" (1872), "The Conservation of Energy" (1874), and "Practical Physics" (1885). Most of these are text-books on the subjects of which they treat. He and Professor Tait also produced the "Unseen Universe," a work of which 12 editions have been published. At the time of his death he was President of the Physical Society, and was a member of the committee appointed to advise the Government on solar physics. We reprint elsewhere from the columns of *Nature*, a more extended account of Professor Stewart's life and works, by his friend and associate Professor Tait.

Franz Carl Guilleaume.

The head of the noted firm of Felten & Guilleaume, of Mülheim on the Rhine, who died on the 1st of December last, from the consequences of an operation, was a manufacturer and an organizer of business of a high order. He was born on the 30th December, 1834, at Cologne, and was a grandson of Franz Carl Guilleaume, who in conjunction with his father-in-law, Theodor Felten, had established the firm of Felten & Guilleaume, in the year 1824.

The deceased assumed sole proprietorship of the firm in the year 1865. His energy, spirit of enterprise and skillful management achieved for the firm a well merited celebrity throughout the business world. The firm's original business was the manufacture of rope and cordage, at Cologne, to which was ultimately added wire, wire ropes and telegraph cables, and the works were removed to Mülheim.

The late F. C. Guilleaume was ever anxious for the welfare of the 2,500 hands and numerous officials in his employ, and has left behind him many providential institutions which will serve to keep his remembrance fresh in their minds. We may mention for instance the numerous dwellings erected for his officials and workmen, and which are exemplary from a sanitary point of view; the co-operative stores with savings bank; an institution for the care of young children during the working hours of their parents; a beneficary fund for deserving employees, unfortunate or disabled, and other similar provisions.

Mr. Guilleaume possessed not only an acute and disciplined mind, capable of devising and executing large enterprises, but, we are happy to say, an enlightened human sympathy, and directed much of his effort to the well being of the large number of persons drawn about him by his large undertakings.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rai per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horse-power; **T.**, T-rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scafe; *Sec.*, Arthur Kennedy; *Supt.*, J. J. Houghton; *Eng.*, Sam'l Drescher; 4 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 250 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Supt.*, G. Johnson; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; water-power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Denver, Col.—Denver Tramway Co.—*Pr.*, Rodney Curtis; *Sec.*, Wm. G. Evans; *Supt.*, Jno. C. Curtis; 4 mi.; g. 36; 16 and 18 lb.; 10 m. c.; sta. 125 h. p.; conduit cond. SHORT-NESMITH.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g.——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE.

Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; 1 mi.; g. 5-2; 56 lb.; 2 m. c.; sta. 80 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. —; 16 lb. T; 1 c.; 1 m.; sta. — h. p.; conduit cond. VAN DEPOELE.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Kansas City, Mo.—Kansas City Elect. Ry. Co.—*Pr.*, W. W. Kendall; *Sec. & Tr.*, Warren Watson; *Supt.* John C. Henry; 2 mi.; g. 4-8½; 70 lb.; 4 m. c.; sta. 80 h. p.; overhead cond. HENRY.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; — lb.; 4 m. c.; sta. —h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. — h. p.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. VAN DEPOELE.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair Ry. Co.—*Pr.*, Theo. Evans; *Sec.*, J. W. Patterson; 2 mi.; g. 5-2½; 45 lb.; 5 c.; 5 m.; sta. 175 h. p.; overhead and conduit cond. DAFT.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt.*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. VAN DEPOELE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. M. Waugh; 5.75 mi.; g. 4-8½; 30 lb.; 3c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Supt.* B. T. Killam; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 7 m. c.; sta. 360 h. p.; overhead cond. VAN DEPOELE.

Wichita, Kas.—Wich. Riverside & Suburban Ry. Co.—*Pr.*, J. O. Davidson; *Sec.*, N. G. Lee; 4 mi.; g. 6-8; 45 lb; 6 m. c.; sta. h. p.; overhead cond.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.75 mi.; g. 3-6; 35 lb.; 1 c.; 2 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb. T; 1 m. c.; sta. 1,000 h. p.; overhead cond. BENTLEY-KNIGHT.

Constructing or Under Contract.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½; 45 lb.; 3 m. c.; 1 m.; sta. — h. p.; overhead cond. VAN DEPOELE.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—6 mi.; g. 4-8½; — lb.; — c.; — m.; sta. — h. p.; overhead cond. SPRAGUE.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; 5 mi.; g. 4-8½; 25 and 56 lb.; overhead cond. SPRAGUE.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper. DAFT.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. VAN DEPOELE.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; 6 m. c.; overhead cond. SPRAGUE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, Chas. D. Haines; *Sec.* F. H. Skeele; 1.5 mi.; g. 4-8½; 25 lb. T.; 2 m. c.; sta. 50 h. p.; overhead cond. DAFT.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.

New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*. E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.

New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.

Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.

Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.

Richmond, Va.—Union Pass. Ry. Co.—*Pr.*, J. T. Brown; *Sec.* and *Treas.*, J. F.

St. Louis, Mo.—Lindell Ry. Co.—*Pr.* J. H. Maxon; *Sec.* and *Tr.* G. W. Baumhoff; — mi.; g. 4-10; storage bats.

Barry; 13 mi.; g. 4-8½; 45 lb.; 20 m. c.; overhead cond. SPRAGUE.

San Jose, Cal.—San Jose Motor Co.—*Pr.*, J. W. Rea.

Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.*, A. Frothingham; *G. M.*, B. F. Killam; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; overhead cond. VAN DEPOELE.

South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; 3.25 mi.; g. 4-8½; overhead cond. DAFT.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond.; VAN DEPOELE.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—7 mi.; g. 5-2; 50 lb.; 2 m. c.; overhead cond. SPRAGUE.

Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

Notes.

FROM statements recently published it appears that the Edison electric cars, operated by accumulators, have run a total distance of over 30,000 miles in London, since August 1, 1887, and that the service has been performed in the most perfect and practical manner. The number of passengers carried per trip shows a marked increase, which is good evidence of the popularity of the system with the traveling public.

WM. WHARTON, JR., of Philadelphia, publishes in the *Electrical World* a challenge to electrician C. O. Mailloux, of the Julien Electric Company of New York, offering to pay all expenses if the latter will bring a Julien electric street car, and make three runs in competition with the Reckenzaun car. Mr. Wharton says: "For every mile that his car makes more than our Reckenzaun car I will pay $100, provided that he pays $50 for each mile that his car makes less than our Reckenzaun car, the money to go to some charitable organization." George B. Prescott, Jr., whose opinion on electric car work is entitled to great weight, makes the very pertinent comment, that in view of the entire absence of any useful data such a test would prove nothing at all, or as he puts it: "To claim that an unknown charge of an unknown battery will propel an unknown car twice as many miles as another unknown battery will propel another unknown car is about as instructive as to say that a locomotive can go further than a horse." Mr. Mailloux has not yet, so far as we have observed, responded to the challenge.

THE JULIEN ELECTRIC TRACTION CO. has been incorporated in New York by William Bracken, L. Willoughby and Edward O. Coles, with a capital of $3,000,000, for the manufacture of electrical appliances and electric railway machinery.

A CORRESPONDENT of the *Electrical World* recommends slate as a great improvement over fibre, mica and other materials ordinarily used, for insulating the brush-clamps of dynamo machines.

PERSONAL MENTION.

Messrs. Wiedersheim and Kintner, of New York and Philadelphia, solicitors of patents and experts in electrical cases, have associated with themselves Mr. Carl Hering, of Philadelphia, as consulting electrician. This is a very well advised step on the part of Messrs. Wiedersheim and Kintner, as Mr. Hering's knowledge and experience of electro-technics will undoubtedly prove of great value in such investigations as are frequently required in the study of inventions or technical questions arising in litigation.

"Dr. Otto A. Moses," says the *Electrical Review* of January 28th, "is still absent in Europe. An electric light convention without the presence of the versatile doctor will not seem at all natural." Our valued contemporary will be glad to be corrected, and to learn that Dr. Moses returned to New York, January 24th, and that his genial presence may fairly be expected at the Pittsburgh meeting.

ELECTRIC LIGHT AND POWER.

THE UNITED STATES ELECTRIC LIGHT CO. has completed its new lamp factory in Newark, N. J., fronting 135 feet on Orange street and 125 feet on Plane street. It is four stories high, and has a 12 foot basement, which is used for the heavy machinery, engines, dynamos, air pumps, etc., for exhausting, and force pumps for the glass-workers employed in sealing the lamps. The laboratory is on the first floor and is fitted out with a complete line of test instruments, some of the most delicate of which are made by the company's own experts. The upper floors of the building are devoted to exhausting, testing and finishing the lamps. The elevators, stairways, wires, etc., are all in separate compartments outside the building. The company is at present about 100,000 lamps and 120 machines behind its orders. In New York city it has recently been engaged fitting out the Metropolitan Life building in Park place and the American Tract Society's building, at the corner of Nassau and Spruce streets, besides large extensions of the plant in the Equitable building. The Philadelphia post-office takes 2,500 lamps. The Troy Electric Light Co. makes a large increase, as do also the Rochester and Newark companies, and altogether about a score of new stations have been started in the last three months.

THE CERTIFICATE of increase of the capital stock of the Zanesville Electric Light Co. from $25,000 to $75,000 has been filed with the secretary of state. Secretary Durban says that this action was taken at the annual meeting in December, although the electric light plant had been increased to that valuation some time before.

HYDE PARK, which is a suburb of Boston, has a population of about 9,000. It is a manufacturing town as well as a place of residence for people doing business in the city. For the past two years the question of lighting the streets by electricity has been agitated, and six months ago the town decided to adopt that form of illumination. The contest for lighting the town was principally between the American and the Thomson-Houston companies. After the appointment of committees and a most thorough examination of both systems, the American was finally adopted by the selectmen, and a contract made with the American Electric Manufacturing Co., of New York, to light the streets with 75 arc lights. The company put in a 100-light plant, and it is said that the installation is one of the finest in Massachusetts. The lights were started on the 14th of January, and according to the local paper, the Norfolk County *Gazette*, the people were jubilant over the occasion. It is said that the town will need 100 lights, and that the mills and stores in the town will use the light to a considerable extent, so that it is safe to say that it will not be long before the present number of lights in the town will be doubled.

THE GAS AND ELECTRIC LIGHT COMBINATION is making satisfactory progress in New England. One of the most recent converts to this system of mixed lighting is the Pawtucket Gas Co., of Pawtucket, R. I., the general manager of which, Mr. Stiness, is

laying out to do a large amount of electric lighting in connection with his gas industry. He is building one of the finest stations in New England, and has adopted the American system, which is now being installed.

A COMMITTEE of the Board of Aldermen of Detroit, Mich., has been appointed to investigate the practicability of the city owning and operating its public electric lighting plant, and for the purpose of obtaining all possible information upon the different systems.

THE MILLS and factories in various sections of New England are going into the electric lighting to a great extent, and the American system, judging by the number of new installations and the satisfaction expressed by the users of the light, is in high favor with them. The Arlington Mills, of Lawrence, Mass., are now using about 450 lights, and it is said the management is contemplating a large addition to the present plant.

Foreign.

Belgium.—The Thomson-Houston Co. has bought some ground at Brussels, in the Champ de Mars, for the installation of steam engines and dynamos for lighting the Théâtre Molière. This company has also arranged with M. Meunig to light in the district of Ixelles, in which the theatre is situated, the Porte de Namur, the Théâtre Café, and part of the Chaussée de Wavre. A proposal has also been made to the local authorities to light the whole quarter electrically instead of by gas, but the offer has not been accepted. Electric lighting is making rapid headway, especially in Brussels, and among those who have lately adopted it are several cafés in the centre of the town, and the Foire de Leipzig emporiums. A syndicate is spoken of to promote the adoption of electric lighting, which will include Messrs. Mourlon, Gérard, & Co., and the Société Industrielle d'Electricité.

England.—ELECTRIC LIGHTING IN LONDON.—Mr. W. Lant-Carpenter delivered an interesting lecture to the members of the County of Middlesex Natural History and Scientific Society on Tuesday evening, at the rooms of the Medical Society of London, in Chandos street, Cavendish square. His subject was: "The Position and Prospects of Electric Lighting in the Metropolis," which he treated in the manner most calculated to commend it to the attention and intelligent interest of his audience; that is to say, the lecture was a "popular" one to a certain extent, but contained a vast amount of information likely to be useful to those of his hearers who may have it in contemplation to make use of the electric light for themselves. The portions of his lecture in which we were most interested were those in which he treated of the "prospects" of the light in London; with its "position" we were necessarily already more or less familiar. A few of the points elicited by Mr. Carpenter from the various companies and lighting firms will be of interest to our readers. The Maxim-Weston Co., he gathered, has almost completed a large installation at the establishment of Messrs. Crisp, in the Seven Sisters Road, where from 40 to 50 arcs, and 300 or 400 incandescent lamps are to be employed. Overtures have been made to the same company for the erection of a central station in the city to light 5,000 lamps. The firm with whom the company is in communication guarantee to take 1,000 lights themselves for three years, and to find customers for the remaining 4,000 lights. Again, certain private individuals have subscribed a large sum to provide for an installation of 1,000 lights in another part of the city. This looks like a promise of great activity in the city during the present year. Further west, Mr. J. E. H. Gordon is putting up an installation of 5,000 lamps for the lighting of a huge building near Whitehall and the National Liberal Club. The E. P. S. company has upwards of 3,500 lamps running from its accumulators in the city, and anticipate a large increase. Messrs. Crompton & Co., have applied for powers to considerably extend the Kensington Court installation, embracing nearly the whole of Kensington, Knightsbridge, Brompton, and a portion of Chelsea, probably the richest part of residential London. Mr. Carpenter visited the Kensington Court station, and was impressed by the compactness of the plant. There are at present 1,000 lamps running, and 500 more are contracted for, all in private houses; there is room at the station for the triplication of the plant and the provision of current for 20,000 lamps. The house furthest removed from the station is at a distance of 900 yards, but Mr. Crompton is confident of his ability to carry current to distances of two or two and a half miles. Current is also supplied for small power motors and for arc lights. The charge imposed is 8d. per Board of Trade unit, or 0.28d. per hour per lamp, amounting to about double the price of gas. The shares in the company which owns this installation are at 50 per cent. premium, a fact which speaks well for the confidence of the shareholders in its success.—*The Electrical Review* (London.)

Germany.—The experiment recently made in Berlin of joining the underground mains of two central stations has proved completely successful. Hitherto the network belonging to each station has been kept distinct from neighboring mains, but as such a subdivision entailed greater administrative expenses and a greater outlay for reserve machinery, the Allgemeine Elektricitäts Gesellschaft resolved to join their two stations, one in the Markgrafenstrasse and the other in the Mauerstrasse, so that during the day time and late at night only one of these stations need be kept at work.

The electric light installation in what is known as the German Theatre, in Berlin, has now been completed down to the smallest rooms. The lamps employed were made by the new company manufacturing the Seel glow lamp. The following is a list of the lamps installed:

Five flies, each three rows of forty lamps, in three colors—red, green and white	600
Two front wings, each twelve lights	24
Flies over the back of the stage	45
Foot lights	42
Auditorium	106
Foyer	200
Cloak and store rooms	150
Stairs and corridors	150
Vestibule, bar and box office	150
Offices	18
Total	1485

On each side of the stage there are five plugs for the attachment of incandescent light cables, and two for arc lights. The latter have separate resistances, whilst the glow lights are regulated by a stage rheostat in groups. The Seel lamps, so far, have stood very well: they can be worked at a high temperature without the risk of breaking, and do not appear to blacken the glass bulbs so much as other forms of incandescent lamps. The manager of the theatre considers the working expenses with the electric light smaller than with gas lights; but in his calculation no allowance has been made for interest on the cost of plant.—*Industries.*

According to *Industries*, an electric locomotive has been built in Berlin, and public trials are announced to take place on a tram line. The motor is in design similar to a Gülcher dynamo, is speeded at 300 revolutions, and connected with the axles by spur gearing. Electric power is supplied by a battery of E. P. S. accumulators, giving 200 volts and a maximum rate of discharge of 40 amperes. The total storage capacity is 300 ampere-hours, and the estimated speed is 7½ miles per hour.

Recent official statistics give the whole number of electric lamps in Germany as 15,000 arc and 170,000 incandescent, operated by a total number of 4,000 dynamos. The total estimated horse-power is about 30,000 (indicated). One firm in Berlin makes 2,000 incandescent lamps per day.

Spain.—In the matter of electrically lighting the Royal Theatre at Madrid, Mr. Edward P. Thompson, of New York, is consulting electrician, under appointment of the Consul General of Spain.

THE TELEPHONE ON THE ALPS.

Telephonic apparatus has been installed with great success in the Hospice of the Great St. Bernard. We may accordingly expect one of these days to see the regions of thick-ribbed ice gleaming under electric beams, as we may already see Bengal lights thrown on the cascades and glaciers of the great Alps. The occupations of the mastiffs who hunt up lost travelers will be gone, and the cowl-clad canon who acts as the benevolent and affable prior of the monastery will be replaced by a ruddy and rubicund Boniface, to whom tourists will telephone for beds. The installation of the telephone amid the sempiternal snows suggests many more peculiar possibilities; but for the present the instrument will be used for a definite and very laudable purpose. The facts of the case are these: Canon Bourgeois, Prior of the Great St. Bernard, took it into his learned head about 12 months ago, that, if telephone offices were organized at St. Remy, in the monastery itself, and at Proz en Valais, the number of fatal accidents annually happening among French and Italian workmen while crossing the mountains between October and May might be diminished. He communicated the idea to Canon Bérard, of Aosta, who took up the matter with energy. M. Bourgeois had invented a telephonic apparatus of his own, and after a while the Swiss and Italian governments gave their respective sanctions to the proposed plans. The Prior was duly authorized to join his telephone to the telegraph wire between Aosta and Martigny. Since then telephones have been in operation at La Thuile, in the Hospice of the Little St. Bernard, and in several of the adjacent cantons. Last Sunday the Canon had a kind of field day with his telephones, and, making the Little St. Bernard his temporary headquarters, he conversed with the brother in charge of the office in the Hospice of the Great St. Bernard, and with the officials in the various cantons.—*Electrical Review* (N. Y.).

NEW INCORPORATIONS.

The Great Falls Electric and Power Co., of Great Falls, Md. Capital stock, $200,000. E. J. Ellis, and others, incorporators.

The Seward Electric Light and Power Co., Seward, Neb. Capital stock, $10,000. John Cattle, and others, incorporators.

The Berkley Electric Light Co., Berkley, Cal. Capital stock, $30.000. R. P. Thomas, and others, incorporators.

The Napa Electric Light Co., Napa City, Cal. Capital stock, $50,000. George L. Henzel, and others, incorporators.

The Hauss Electric Manufacturing Co , Cincinnati, O. Capital stock, $250,000. David J. Hauss, and others, incorporators.

The Seneca Electric Light Co., Seneca Falls, N. Y. Capital stock, $60,000. Simeon L. Phillips, and others, incorporators.

The Mahanoy City Light, Heat and Power Co., Mahanoy City, Pa. Capital stock, $15,000. W. L. Yoder, and others, incorporators.

The Conshohocken Electric Light and Power Co., Conshohocken, Pa. Capital stock, $20,000. T. H. Seeble, and others, incorporators.

The Union City Electric Light, Gas and Water Works Co., Strong City, Kas. Capital stock, $10,000. W. P. Martin, and others, incorporators.

The Rutland Electric Co., Rutland, Vt., have increased its capital stock by $25,000, and will make extensive improvements to its plant.

The Piscataquis Woolen Co. contemplate the establishment of an electric light plant at their mill at Guilford, Me.

C. H. Dexter & Sons will erect an electric light plant at their mills at Windsor Locks, Conn.

The Citizens' Electric Light Co., New Albany, Ind., will erect a plant.

The Buffalo Illuminating Co., Buffalo, N. Y. Capital stock, $100,000. Daniel E. Bailey, and others, incorporators.

The Roodhouse Electric and Power Co., Roodhouse, Ill. Capital stock, $5,000. Ellis Briggs, and others, incorporators.

The Presque Isle Electric Light Co., Presque Isle, Me. Capital stock, $10,000. James W. Bolton, and others, incorporators.

The Weston Electric Light Co , St. Louis, Mo. Capital stock, $60,000. F. L. Johnson, and others, incorporators.

MANUFACTURING AND TRADE NOTES.

ALFRED F. MOORE, successor to Jos. Moore & Sons, manufacturer of insulated wire for all electrical purposes, Philadelphia, announces that Mr. Chas. C. King and Mr. Antoine Bournonville have been admitted to an interest in the profits of his business, the firm name remaining as heretofore.

THE POPE MFG. Co., of Boston, have issued a novel business calendar and stand for 1888, of special interest to wheelmen. It is called the Columbia Bicycle Calendar. In this calendar a new departure has been made. The calendar proper is in the form of a pad, containing 366 leaves, one for each day in the year, to be torn off daily. The pad rests upon a portable stand, and when placed upon the desk or writing table the entire surface of the date leaf is brought directly, and left constantly, before the eye, furnishing date and memoranda, impossible to be overlooked. Upon each slip appear fresh quotations pertaining to cycling from leading publications and prominent writers—a collection which illustrates the popularity and universality of cycling the world over.

THE GLOBE ELECTRIC Co., Cleveland, Ohio, manufacturers, importers, and dealers in electrical apparatus and appliances, issue a circular describing a number of novel and convenient sets of domestic apparatus, as call-bells, annunciators, etc. They make a specialty of this class of work.

MESSRS. CHAS. A. SCHIEREN & Co., report sales of leather link belting to the following concerns for use on dynamos. Plainfield Electric Light Co., Plainfield, N. J., 46 feet, 14" standard link belt. Edison Electric Ill. Co., New Orleans, La., 43 feet, 10" standard link belt—53 feet, 10" standard link belt. Peoples' Electric Light Co., Trenton, N. J., 42 feet, 10" standard link belt. Pennsylvania Pulp and Paper Co., Lock Haven, Pa., 30 feet, 6" standard link belt. Edison Machine Works, Schenectady, N. Y., 44 feet, 8" standard link belt.

THE SHULTZ BELTING COMPANY, of St. Louis, a prominent local industry, had an opportunity to display remarkable enterprise a few days ago. It came when the Brush electric light plant was burned out, completely destroying all the belting of that extensive establishment. The consequence was that darkness hung over the stores of the company's patrons, and they began calling for electricity. There was no way of producing a current without belting, and as the sizes wanted were of such unusual dimensions none could be found in stock. Therefore, the Shultz Belting Company began that afternoon to manufacture belting from the leather which they had on hand. By working their forces night and day they succeeded in having the Brush plant in full operation again at 3 o'clock Monday afternoon. In the meantime, five double 12-inch, one double 20-inch, one double 24-inch, 210 feet of 12-inch, 72 feet of 20-inch and 72 feet of 24-inch leather belting was cut, made and fitted accurately to the electric pulleys. This is thought to be the quickest job ever accomplished in this line of manufacture, and is fully in keeping with the enterprise of the firm, which is second to none in the country.

THE SHAVER CORPORATION, 157 Broadway, New York, manufacture and supply Mr. Shaver's Mechanical Telephones. Mr. Shaver has given much attention to making serviceable telephones for short distances on the mechanical principle of the old "lovers' telegraph." Such telephones render excellent service on short lines properly constructed. There is evidently a very considerable field for their introduction.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall Street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From Dec. 20th, 1887, to Jan. 17, 1888 (inclusive).

Alarms and Signals:—*Signal-Box*, M. Martin, 375,063, Dec. 20. *Hotel Signal*, H. B. Cox, 375,442. *Automatic Cut-Out for Fire-Alarm Box Controllers*, C. D. Rogers, 375,569. *Electric Call-Box*, L. B. Firman, 375,617. *Fire-Extinguisher and Alarm*, C. E. Kells, Jr., 375,636, Dec. 27. *Fire Alarm Circuit*, J. P. Barrett, 376,133. *Receiving, Transmitting and Distributing Instrument for Electro-Magnetic Thermoscopes*, H. J. Haight, 376,149. *Annunciator*, J. P. Tirrell, 376,171, Jan. 10.

Conductors, Insulators, Supports and Systems:—*Clip or Hanger-Clasp for Supporting Cables, &c.*, T. T. Eckert, 374,948. *Insulator*, E. C. Emery, 375,276. *Insulated Electrical Conductor*, A. Kissell, 375,295, Dec. 20. *Underground Electric Conductor*, DeW. C. James, 375,633. *Flexible Standard and Conductor for Electric Lights*, E. C. Fasoldt, 375,702, Dec. 27. *Conduit for Electric Conductors and Power Cables*, I. LaR. Johnson, 375,876. *Covered or Insulated Wire or Conductor*, L. F. Requa, 375,952, Jan. 3. *Pole-Indicator for Electric Conductors*, A. Berghausen, 376,281, Jan 10. *Electric Conduit*, R. Van Buren and J. J. Powers, 376,562, Jan. 17.

Distribution:—*Cut-Out for Electrical Distribution Apparatus*, M. M. M. Slattery, 375,014, Dec. 20.

Dynamos and Motors:—*Dynamo-Electric Machines*, J. Gray, 374,959. *Combined Electric Motor and Fan*, H. H. Blades, 375,255, Dec. 20. *Electrical Converter, Motor and Generator*, R. Eickemeyer, 375,542. *Electric Motor*, J. F. McLaughlin, 375,560. *Electric Motor*, E. Julien, 375,676, Dec. 27. *Armature for Magneto-Electric Machines*, W. Humans, 375,750. *Magneto-Electric Machine*, same, 375,751. *Regulating Alternate Current Electric Generators*, K. Zipernowsky and M. Deri, 375,910, Jan. 3. *Dynamo-Electric Machine or Motor*, E. Thomson, 376,120. *Dynamo-Electric Machine*, F. Jehl, 376,307. *Armature for Dynamo-Electric Machines*, H. Lemp, 376,326, Jan. 10.

Galvanic Batteries:—*Galvanic Battery*, J. Serson, 375,007. *Carbon Electrode for Galvanic Batteries*, C. H. Wilder, 375,034, Dec. 20. *Galvanic Battery*, H. B. Cox, 375,441; J. F. McLaughlin, 375,559. *Primary Electric Battery*, same, 375,561, Dec. 27. *Battery Zinc*, J. Beattie, Jr., 376,228, Jan. 10.

Ignition:—*Electric Gas-Lighting Apparatus*, C. B. Bosworth, 375,118, Dec. 20. *System of Electric Gas-Lighting*, W. H. Doering, 375,414. *Sparker-Coil for Gas-Lighting*, R. Eickemeyer, 375,614, Dec. 27.

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THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS, JR.

PUBLISHED MONTHLY BY

THE ELECTRICAL PUBLISHING CO.,

115 Nassau Street, New York city.

TERMS OF SUBSCRIPTION.

United States and Canada, per annum,	$3.00
Four or more Copies, in Clubs (each) "	2.50
One Copy, Four Months,	1.00
Great Britain and other Foreign Countries within the Postal Union "	4.00
Single Copies, -	.30

[Entered at the Post Office at New York, N. Y., as second class mail matter.]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of the* ELECTRICAL PUBLISHING CO. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

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VOL. VII. NEW YORK, MARCH, 1888. No. 75.

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"SYSTEMS."

THAT the author of the valuable contribution to electrical literature, known as "Primer No. 0," was a profound student of the tendencies of modern electrical arts, is sufficiently evinced by his sapient remark that "dynamos may be painted of various colors without increasing their efficiency." The same result which was aimed at in 1884, by means of chromatic effulgence, is in these later days sought to be attained by the more or less ingenious application of the much abused word "system." This process has perhaps reached its highest development in connection with electric railway inventions. For example, let us start with the assumption that there are, say, four ways of supplying electricity to a motor on a moving vehicle, viz:—by an overhead wire, a supplementary conducting rail, an underground conduit, and a storage battery. These, let us say, constitute the respective systems of Smith, Brown, Jones, and Robinson. Now, John Doe, by substituting his own form of motor for that of Smith, in the first named organization, produces the "Doe system;" or if he is mentally unequal to the task of devising a motor of his own, or even of purchasing one in open market and repainting it, he can at least take the motor of either Smith, Brown, Jones, or Robinson, and substitute it in some one of the other systems, which will answer every purpose. This gives him a choice of twelve different combinations, besides the four with his own motor, and it would indeed be a pity, if having sixteen different combinations to choose from, the "Doe system" should not be a pretty good thing. Richard Roe, on the other hand, takes Robinson's motor and storage battery, and substitutes an alloy of somewhat different proportions in the battery plates, and behold! "Richard Roe's system of electric traction." Occasionally, however, the claims of these rival inventors clash with each other and give rise to hard feelings, and much-to-be regretted recriminations. For instance, Jobson and Dobson invent a "system" by combining Smith's conductor with Jones's motor, contemporaneously with the invention by Hobson and Wobson of another "system" due to the combination of Smith's motor with Jones's conductor. Thereupon the advertising, business notices, and correspondence columns of the trade journals resound with the clamors and contentions of Dobson, Hobson, Jobson and Wobson, and of their general agents, local agents, and advertising agents, until everybody is tired.

Of course all this is a great pity, but as it is wholly due to the "system," there is no apparent remedy. In the case of the ordinary every-day street railway, if any one should publicly announce that he had invented a new "system" of street railway traction, which consisted in the use of mares or of mules, public ridicule would speedily put an end to his pretensions. But electricity is a mysterious agent. Nobody knows whether it is a fluid, or a force, or a mode of motion, and, therefore, it is only necessary for the originators of new electrical "systems" to discourse learnedly of "fundamental patents," "coefficients of mutual induction," and of "magnetic saturation," and the like, to convince the public that they have really got hold of something very extraordinary.

Seriously, if this silly affectation of calling every trifling modification of a well-known organization a new "system" is carried much further, the electricians of America will be in no small danger of rendering themselves the laughing stock of the world.

THE ELECTRIC LIGHT CONVENTION AT PITTSBURGH.

THE last meeting of the National Electric Light Association was in all respects interesting and important. We devote the greater part of our present enlarged number to the papers read at the meeting, and the discussions and proceedings of the Convention. The twelve papers read and discussed were all upon topics of practical and immediate interest to the art and business which underlie the association and give it its name. Much light was thrown upon questions relating to the employment of new methods, both electrical and mechanical. Distribution by alternating currents and converters formed a leading topic of consideration, while underground wires received scarcely less attention; both subjects were ably presented in papers read and discussed. Electric motors were treated theoretically on the electrical side, and practically on the business side. The proper adaptation of steam power plant to electrical distribution, improvements in leather belting, and the automatic recording of steam pressure, were among the mechanical subjects of papers and discussion. Other topics, closely allied to electric lighting, were the protec-

tion of watches from magnetization, and the relation of electric lighting to fire insurance. The full text of all of the papers will be found in our present issue.

The action of the Association in raising the annual membership fee to $20, and in employing a permanent Secretary seems very judicious, and should tend to increase largely the usefulness of the organization.

In treating the question of reform in the patent system, both the committee on that subject and the Association have wisely recognized the danger of attempting a general revision by a commission, as at first proposed, and confined their action to approving an effort for two specific changes—an increase in the salary of the Commissioner of Patents, and the creation of an Appellate Patent Court.

ELECTRIC RAILWAYS FOR CITY TRAFFIC.

The results of the operation of street-railway cars by accumulators, while thus far not in all respects entirely satisfactory, have been at least sufficient to place it beyond question that the cost of this mode of traction is somewhat less, probably materially less, than that of animal power. At least four independent sets of experiments under different conditions, have been carried on during the past year, in Boston, New York, Jersey City and Philadelphia, and a general review of the results shows that the accumulator itself has proved equal to the requirements of the service. Of course it would be desirable if the ratio of yield of power to the weight and cost of the accumulator could be increased, as it doubtless will be; but even if this expectation should not be fulfilled, we are fully satisfied that the work can be done, and done with entire satisfaction by means of the accumulators now on the market. The principal need for improvement now lies in the adaptation of the motor to the conditions of electric supply on the one hand, and to the requirements of the running gear of the car on the other hand. Great improvements in both these respects have been made within a few months, and it seems certain that the coming season will see the problem successfully solved, possibly in more ways than one.

It is gratifying to learn that the conduit system of electric distribution, which has quite recently been put into actual service in a city street, is thus far giving excellent satisfaction. If this method of supplying the electric current to the cars prove to justify the expectations of its friends, it is not too much to say that every dollar hereafter invested in cable systems for lines of level and moderate grades, in our large cities, will be absolutely thrown away. In all probability, the present year will see the question settled beyond a peradventure.

DISASTROUS ECONOMY.

In a recent article, we had occasion to comment upon the deterioration in the quality of the telegraphic service which has become so apparent in recent years, which in our opinion may be traced in a large measure to the growing practice of entrusting important business to the hands of immature boys and girls. Many of these young operators are not only deficient in judgment, but are quite innocent of any adequate sense of responsibility. The truth of our remarks has almost immediately received an unexpected and startling confirmation in the shape of the statistical table of railway accidents just published in that accurate and trustworthy journal, the *Railroad Gazette.* This summary shows that the number of butting collisions on the open road, directly caused by mistakes in and concerning telegraphic train orders, have increased in 1887, no less than *fifty per cent.* over the returns of the two preceding years. We give the precise figures from the *Gazette's* table.

Number of collisions in 1885	120
" " " 1886	127
" " " 1887	309

It appears upon investigation, that the greater part of these disastrous blunders are made at headquarters, that is to say, in the train despatcher's office, a point at which there can be no excuse whatever for inefficient service except that of false economy. It is nothing less than criminal folly to place even the temporary responsibility of controlling the movements of trains on an important railway, or in fact on any railway whatsoever, in the hands of a half-grown boy, but it is nevertheless sometimes done, and the results are occasionally such as might have been anticipated. We endorse to the full, the opinion of our contemporary, that a road which cannot afford first-class talent in the despatcher's office has no right to run trains.

The destruction of life and property caused by 309 butting collisions in one year would go a long way towards paying for the necessary "talent" on the roads on which they occurred.

The *Gazette's* remarks on the same subject are very much to the point, and will bear quoting. The editor says :—

> There can be little doubt that many operators are too young and that some are too old, and that a little inspection would disclose numbers of them whose habits of mind and sense of responsibility are loose and unsystematic. These at least will bear looking after; and where the rule requiring the consent of the ruling train to be always first obtained, is laid aside or suspended simply from lack of offices, operators or despatchers, it will be well to consider whether the lives of passengers and trainmen and the reputation of the road do not demand an increase of facilities in this direction. Whatever be the system in use it cannot be too strongly insisted that those engaged in the issue and delivery of train orders should be under constant and careful supervision. This is unfortunately too often neglected, with resulting carelessness on the part of operators and trainmen in this important branch, until attention is called to the deficiency in management by some serious calamity.

We do not know whether this subject is one which properly falls within the jurisdiction of the inter-state commerce commissioners, but it is very certain that a searching investigation by some competent authority is very much needed. The figures proclaim this so loudly that it hardly seems necessary for us to enlarge upon it.

Under the title, A Warning from the Edison Electric Light Co., appears a well written and well printed pamphlet of 84 pages, put up, not inappropriately, in covers resembling in color a Chinese fire-cracker. In this publication particular attention is paid to the case of the Consolidated Electric Light Company and "its new partners, Mr. George Westinghouse, Jr., and the Thomson-Houston Electric Company." The validity of the Edison lamp patents is affirmed over the signatures of William M. Evarts, Clarence Seward and John C. Tomlinson; the futility of all guarantees in behalf of any other electric system than that of Edison is pointed

out; the utter and absolute inutility of the alternate inductive system of electric distribution, is fully established so far as language is competent to effect that end, and the public is solemnly warned against the disastrous results, physical and pecuniary, which will be entailed by its use.

In the appendices, it is satisfactorily established that the first cost as well as the working expenses of the alternate system are much greater than that of the direct system of distribution, and in connection with this subject the following conundrum is propounded :—" It will be interesting for the Westinghouse enthusiast to glance at patent No. 278,418, allowed to Mr. Edison, May 29th 1883, for translating electric current from high to low tensions, and to speculate as to whether, if there were any financial value to the Westinghouse claims, the Edison company would allow a competitor to revel in undisturbed enjoyment of it."

We have speculated "as to whether" and frankly say that we give it up. But it is still more difficult for us to understand why it should be deemed necessary for the president of the Edison Company to issue such a grave proclamation against a competitor which offers a system not merely worthless and dangerous, but one which is sold at a higher price and costs more to operate, while at the same time it creates exasperation—not unmixed with terror— among its consumers, wherever it is in use.

The usual list of 345 Edison patents concludes the *brochure*, and will be found valuable for reference. We presume Mr. E. H. Johnson, president of the Edison Company, 16 Broad st. N. Y., will be pleased to furnish copies of the work to all seekers after the truth.

THE illustrated journals and magazines are paying considerable attention to electrical matters at the present time. In *Harper's Weekly* of February 25th, Mr. S. S. Wheeler has a very interesting article on Recent Developments of Electricity as an Industrial Art, in which the leading features in the modern developments of electrical science are sketched with a facile pen. The accompanying illustrations are numerous and excellent. Mr. F. L. Pope, writes of the Electric Motor and its Applications in the current number of *Scribner's Magazine*, giving a historical sketch of the evolution of the electric motor, and a succinct account of some of its already numberless modern applications. It is interesting to note that the true place of the electric motor, in the domain of mechanics, though early foretold by Professor Joseph Henry, has only been properly appreciated within the last fifteen years. This article is embellished with portraits of Ampère, Arago, Werner Siemens and Page, as well as with examples of stationary and railway motors. The same author will have an illustrated article in the April number of the *Century* magazine on the American Inventors of the Telegraph, in which special prominence will be given to the contributions thereto of Alfred Vail, which have never received the consideration which their importance deserves. Much unpublished material has been drawn upon, both for text and illustrations, and the paper will form an important contribution to the history of the electric telegraph in America. The illustrations will be abundant, and of the finest character. The publication of such papers as these will serve still further to stimulate the growing popular interest in electrical industries.

THE reception given by the Electric Club, at the formal opening of its house on the evening of January 31, was heartily enjoyed by a large company of members and invited guests. The ceremonies and festivities have been fully described in the daily and weekly press. We regret that we have not space to reprint the admirable address by Professor Rowland on "The Electrical and Magnetic Discoveries of Faraday," which constituted so prominent a feature of the evening. The club house has been decorated and furnished with much good taste, under the enthusiastic direction and supervision of Mr. H. C. Davis, the president. The conveniences and pleasures provided by the club, will doubtless be highly appreciated and largely availed of by members and friends.

IT is to be hoped that the distinction between legitimate journalistic enterprise and vociferous buncombe, seasoned with unwarrantable brag, which is so little observed by some leading daily newspapers, will not be obliterated in the management of any technical journal.

A circular recently issued by the publishers of an electrical periodical, which in many respects deserves and receives praise and support in electrical circles, savors too strongly, we regret to say, of disingenuous journalistic bluster. If reports are to be believed, the questionable circular led to an unseemly personal altercation at Pittsburgh, during the Electric Light Convention, between rival journalists. Why not leave the brag and bluster, brethren, to the quarreling dailies, and keep serenely in mind the constantly expanding field of electrical arts, in which there is likely to be room and verge enough for all to do good work and earn their money for some time to come.

IT is very painful to be constrained in the interest of justice, to publish information reflecting upon an American inventor; but disagreeable things have to be done sometimes. Our attention has been called to an article on the "Jack-knife" switch in the "Dictionaire Théorique et Pratique d'Électricité et de Magnétisme," now coming out in Paris, in which the following statement is made: "This name was given it because at the start the contact spring was arranged like a knife-blade, and because the invention was due to a French Canadian named Jack."

The "Jack-knife," now a curious relic of early telephone-exchanges in America, is still used by the French, who have doubtless carefully investigated its origin. Will not Mr. Scribner, who has hitherto been credited with the ingenious contrivance, now feel called upon to confess, and disclose the surname of the Canadian Jack, from whom he purloined the invention?

THE growth of the American Institute of Electrical Engineers keeps pace with the increasing spread of electrical work. The membership roll has more than doubled since the annual meeting ten months ago, and the rate of increase is steadily maintained from month to month.

Dr. Duncan's paper on Alternate Current Motors, read at the February meeting, and which we print in this issue, treated clearly and instructively a most timely topic. A very interesting feature of the discussion that followed, was Lieutenant Patten's design for a motor on the principle set forth by Professor Thomson at the Institute last May.

ARTICLES.

MR. R. EICKEMEYER'S DYNAMO.

In a notice of Mr. Stephen D. Field's motor experiments on the Thirty-fourth street branch of the elevated railroad, in the October number of the Electrical Engineer, it was mentioned that the current was furnished by a dynamo designed and constructed by Mr. R. Eickemeyer, of Yonkers, N. Y.

The illustrations in the present article show a machine of this type. It has been called an "iron-clad" dynamo, and an examination of the illustrations shows that it is in fact iron-clad throughout.

Figure 1 shows the machine complete, and figure 2 is a view of the same machine with one side of the iron covering removed.

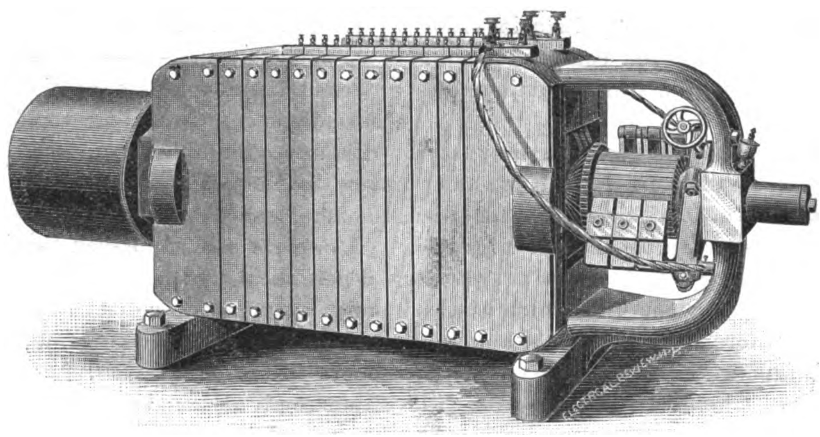

Fig. 1.

It will be seen that the armature is enclosed in the field coils, and that its core is in reality the electro-magnet, the iron covering forming, as it were, the yoke pieces, completing the magnetic circuit. The field coils thus enclose the armature and are in turn enclosed by a rectangular iron frame, forming part of the magnetic circuit, and constituting the backbone of the machine.

To furnish a proper support for the commutator end of the armature shaft the frame is extended beyond the field coils, and encloses the commutator and brushes.

The field winding is composed of a number of coils separated by spaces, to allow a free circulation of air; provision is also made to allow variations in the connections of the field coils for regulating purposes. A hand screw is provided by means of which the brushes, which are of the usual type, can be accurately adjusted.

Figures 3 and 4, which represent cross-sections of the machine, show in detail the relative position of the armature, field coils and the surrounding shell. This disposition of the field coils, causes all the lines of force produced by the current in the field coils, to pass through the armature core and to complete their circuit through the outer cast iron shell.

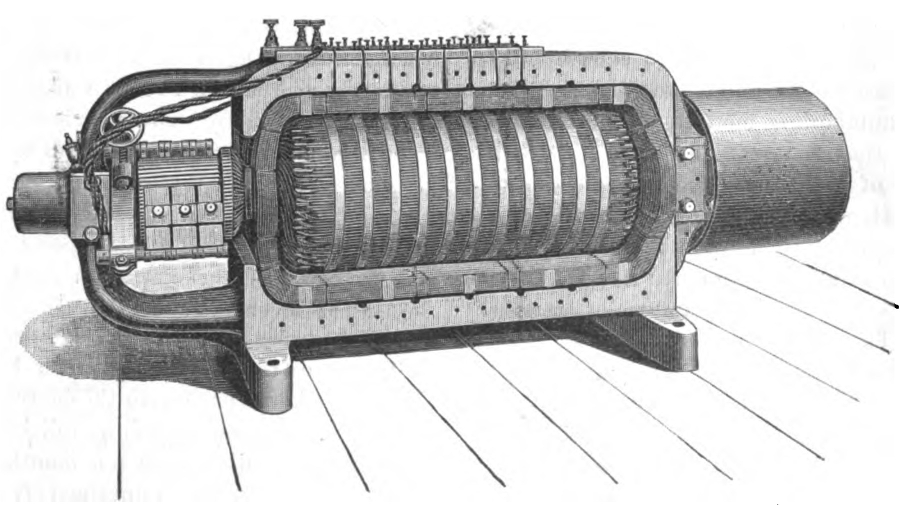

Fig. 2.

If this shell is of sufficient cross section no lines of force appear on the outside, and all loss by leakage is prevented, and as the whole frame serves as a carrier of lines of force all the cast iron in the machine serves a useful purpose, not only as a frame but also as a part of the magnetic circuit.

While the machine thus differs radically from dynamo machinesof the various types heretofore constructed in the disposition of the field wire, it also differs from them in the form and method of its armature winding.

The armature of the machine shown in figures 1 and 2, has 44 coils of four windings each. These coils are wound upon a shaping frame, and when finished and thoroughly saturated with insulating material, are placed upon the cylindrical core, secured by the pins at the ends and bound around the circumference in the usual manner.

To cover the drum or core after the coils are made, or to remove the coils again, is the work of but a few hours. To wind the coils on the shaping frame is a very simple operation, and can be performed by ordinary workmen very rapidly.

Figure 5 represents an armature covered with 44 coils of eight turns each, and figure 6 shows one of these coils.

The advantage of this armature winding, aside from the facility with which the coils can be made and put in position on the drum are:

All the coils of the armature and every turn of every coil are absolutely of the same length.

All the wires in each coil and all the coils on the armature are parallel to each other throughout their whole length.

The coils when wound are ready to be covered with insulating material, and can be tested thoroughly before they are put on the core. Should a defective coil be discovered after the armature has been completed, or should any coil become defective by accident, the coils can be readily taken off, the defective coil or coils replaced by perfect ones, and the whole put back on the armature again in less time than it would take to unwind an armature of the ordinary construction.

Another feature in favor of this mode of winding an armature is that the wires leading across the ends of the drum occupy less than half the space the same quantity of wire would occupy in the ordinary methods of winding armatures, and each coil lying parallel to the preceding one (throughout its length not a single wire crossing any other) the danger of burning out the armature is reduced to a minimum.

The above shown method of winding armature coils and inclosing the armature in the field coils, is also applicable to machines having four or more poles, and this furnishes a means to produce an armature absolutely balanced mechanically as well as electrically. The tests made on machines of this type, indicate that the quantity of material required to produce a given out-put is less than two-thirds of that necessary in a machine of the ordinary form.

The machines being perfectly balanced mechanically, magnetically and electrically, there is no sparking at the brushes, and a change in the adjustment of the brushes is only required with extreme variations of the current taken off, and is even then very slight. The efficiency is as high

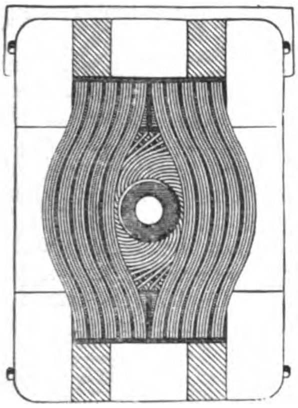

FIG. 3.

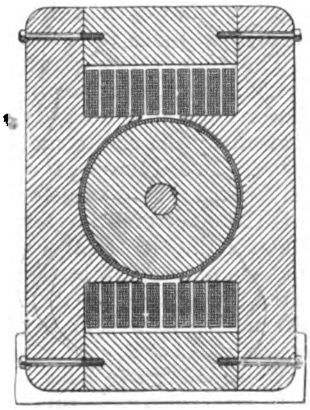

FIG. 4.

as in the best machines constructed. From a mechanical point of view, it appears that all the parts are securely protected, and yet are easily accessible. The machine as a whole, is compact and strong, and may be easily taken apart and remounted.

work, and I made many attempts to devise some method of simplifying the operation. Finally I perfected the winding as now made. The first large machine built was the one used to furnish the current for Mr. Stephen D. Field's motor, tried on the elevated railroad. Its performance far exceeded our expectations. The absence of sparking at the commutator showed that the machine was as well balanced electrically as could be desired, and, all in all, the machine seemed to be a step in the right direction.

"My electrical experiments covered the space of a good many years, for they were only carried on at odd times, when they did not interfere with our regular business—the manufacture of hat machinery."

ALTERNATING CURRENT ELECTRIC MOTORS.[1]

BY DR. LOUIS DUNCAN.

THE alternating system of electrical distribution, possessing as it does many advantages for distributing electrical energy over extended areas, possesses certain disadvantages, among others that of not, at present, allowing the use of electric motors for the distribution of power. Let us, before taking up the special subject for consideration to-night, briefly review the general subject of alternating current distribution.

In this system are employed currents of high and constant potential, varying from positive to negative many times a second. If we represent current and potential by curves whose heights above a horizontal line represent amperes or volts, the horizontal distance representing in-

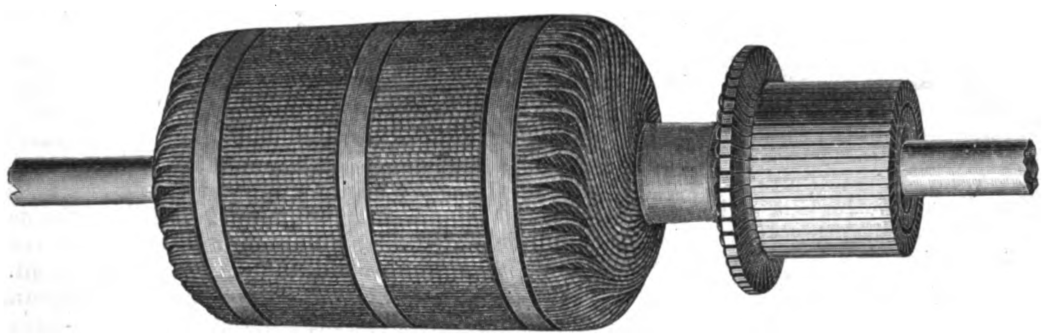

FIG. 5.

MR. EICKEMEYER, who has achieved a wide reputation as an inventor and manufacturer of machinery, for the manufacturing of hats, an industry which he may be said to have revolutionized, furnishes us the following note on the steps that led him to develop and perfect his dynamo.

"When Professor Bell astonished the world with his telephone I became very much interested in that new wonder and, like a good many others, I began to experiment.

"My experiments were on magneto-telephones, and the step

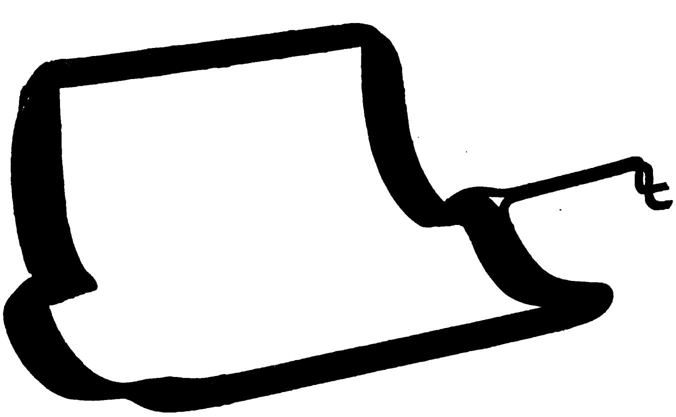

FIG. 6

to dynamo was a natural one. I made a great many dynamos of one type and another, steadily approaching the iron-clad form, and the machine as you know it is the result of experience gathered in their construction.

"The winding of the armature I found a troublesome piece of

tervals of time, we will have something like the following: Figure 1: II representing current, I representing electromotive force; the maximum value of the current lagging behind the maximum of E. M. F. in a way that you were shown recently by Mr. Stanley.

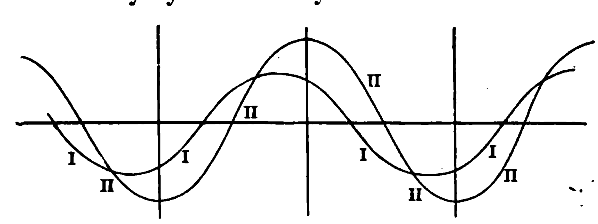

FIG. 1.

The high potential used in the dynamo or primary circuit would not be suitable for incandescent lighting and would be dangerous; it is, therefore, reduced to a low potential at points of consumption by "transformers;" that is, induction coils working backward. Now, the whole beauty of the system lies in this, that by using high potentials in the primary circuits we can transmit a great deal of energy with comparatively little current and, therefore, with little loss in the lines. This enables us to use small conductors and to avoid the large investment in copper necessary in distributing energy by the direct system.

In any central station supplying electric lights the full capacity of the plant is utilized but a short time during the day, and taking the whole 24 hours we will find that we

1. Read before the American Institute of Electrical Engineers, Feb. 14, 1888.

have sold an amount of energy equal to a half or a third—perhaps even less—of the amount we could supply supposing there was a demand for it all. Let us represent by a curve, figure 2, the amount of current used during the day in a constant potential system; the potential being constant, the energy will vary with the current, it being equal to E C.

The amount of energy we could have sold is represented by the total area A O X B; the amount we have sold is the area D E F G H I X O. If we had been able we would have three times the receipts, with expenses perhaps half again as much as in the first case.

A great problem before electricians is to fill the vacant spaces, A D E F G H A and H I B. There are two ways to partially accomplish this. Suppose, in the first place, we put electro-motors on the circuits and sell power during the day. What effect will that have on our diagram? If the motors are at work from 7 A. M. to 6 P. M. we can sell so much power as will at no time make the sum of the

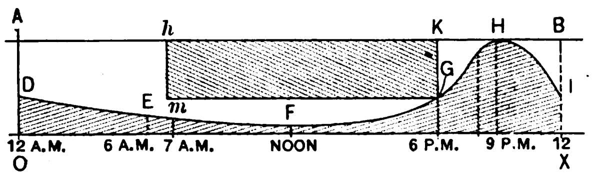

FIG. 2.

power and the energy used for lights greater than the maximum capacity of our station. The area representing the power we can thus sell is shown by G K L M on the diagram. The total solid part of the diagram is all that an alternating system can supply; the direct system could fill the entire area by using storage batteries.

Our knowledge on the subject of alternating currents is largely due to the work of M. Joubert and Dr. John Hopkinson. The latter showed first that alternating dynamos could be coupled in parallel, and afterwards that one dynamo could be used to drive another as a motor. He brought forward experiments tried by Professor Adams and himself, in which one dynamo had driven another, the latter doing mechanical work. Mr. Siemens at the same time, in 1885, described experiments where he had driven both alternating dynamos and ordinary series motors by alternating currents. Dr. Hopkinson's mathematical work assumes that the curve representing E. M. F. is a simple sine curve; that is, that $E = E_0 \text{ sine } 2 \pi \frac{t}{T}$; it is important to notice, however, that his principal conclusions do not depend upon this assumption, but would be true if the E. M. F. were any periodic curve. Since that time nothing of importance has appeared on the subject excepting two short papers, one by Mr. Kapp on "The Maximum Work Obtainable from a Given Source of E. M. F.;" the other by Mr. Blakesly on "Conditions of Maximum Efficiency in the Case of Transmission of Power by Alternating Electric Currents."

In all of the mathematical work done on this subject it has been assumed that the various E. M. F.'s may be represented by a sine curve, and that only simple electro-magnetic actions enter into the problem. I do not believe that these assumptions are true. Since Joubert's experiments, made in 1881, it has been known that the curve of E. M. F. of a Siemens alternating dynamo, where the external circuit had no statical capacity, was very nearly a sine curve. With some of the machines used to-day, and under the much more complicated conditions of distribution, this is probably not even approximately true. Neither is it true that the statical actions of the different forms of wire upon each other in the transformers can be neglected. Messrs. Hutchinson, Wilkes, and myself have lately experimented on this subject, and we have obtained the curves for the currents in the secondary and primary circuits under many conditions. These observed results do not agree with the results of calculation in the few cases that we have worked out. Until we have fully satisfied ourselves in this matter I will avoid any but the simplest mathematical work.

Alternating current motors are not in successful use; let us try to find out the difficulties they present and attempt to suggest plans for overcoming them.

The energy being transformed at any moment in any dynamo-electric apparatus—in which I include dynamos, motors, transformers, etc.—is equal to the product of the current by the electromotive force produced by the apparatus. In a dynamo, for example, the amount of mechanical energy being transformed into electrical is E C, where E is the electromotive force produced by the dynamo; in a motor the electrical work transformed into mechanical is e C, where e again is the E. M. F. produced by the apparatus, the counter E. M. F. of the motor. This is true for alternating as well as for direct current apparatus. Generally we have:

Work $= E\ C$. This is + for a dynamo — for a motor.

In alternating circuits E and C are constantly changing. If we represent them by curves, as before, we must multiply each value of C by the corresponding value of E, and if we add all these together from A to B, figure 3, we will have the work done by the current in one period. Now, if we consider values above the horizontal + and below it —, we have from e to d a + value of the product, from c to d a — value, from c to b a + value, from b to a —. The total work done then is $[e \text{ to } d] + [c \text{ to } b] - [d \text{ to } c] - [b \text{ to } a]$.

Now we see that if we shift II forward or pull I back, we have this work less even, though the curves themselves remain the same size. Now this is one of the exceptions I take to the alternating system. In a direct system as the work decreases the current decreases, and the heating of the mains becomes proportionally less, since it varies as C^2; for example, if the maximum loss in the mains of a direct current plant were 10 per cent. of the average, I imagine that the average loss is not over 3 per cent. In an alternating current plant, a decrease in the consumption of energy decreases the current very little; it simply shifts its position with respect to the E. M. F., and the heating, approximately equal to $\frac{C_0^2}{2} R$, remains nearly constant. A maximum loss of 2.5 per cent. would probably mean an average loss of at least 2 per cent. This same remark applies to

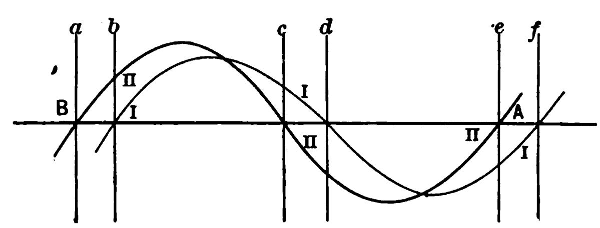

FIG. 3.

transformers and motors, and the average efficiency of the former will be considerably less than the maximum efficiency.

A distinction between continuous and alternating current apparatus is this: In continuous current dynamos and motors the cores making up the windings of the armatures make different angles with the lines of force in the field, and the result, when the armature rotates, is a constant E. M. F. fluctuating but little; in alternating dynamos and motors the alternate coils are symmetrical with respect to the alternate poles, the remaining coils being symmetrical with respect to similar poles of opposite signs. The result is a varying E. M. F., changing as has been shown. In dynamos the effect of this is that the power applied either varies from zero to a maximum each period, or the armature changes its speed at different points and oscillates with a period equal to that of the E. M. F.

Let us now consider what takes place in the case of two motors, one continuous, the other alternating, one between mains where a constant continuous E. M. F. is maintained, the other where there is a constant alternating E. M. F. In the first case representing current and E. M. F. by curves, we have been doing, we will have two straight lines, fig-

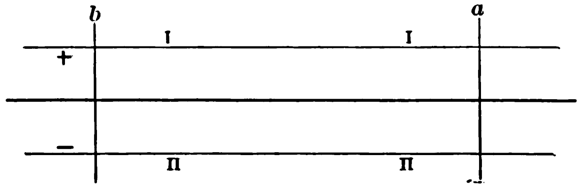

FIG. 4.

ure 4, one above, the other below our horizontal axis, the former representing current, the latter the counter E. M. F. of the motor. Reckoning time along the axis we have for the energy transformed in the interval from a to $b = -$ $C\,E$. As this is — it means that electrical is transformed into mechanical work.

Now, let us consider an alternating current motor built like an alternating dynamo, the field excited by a continuous current. If A B C, figure 5, are the poles of the field magnets, supposed to be excited by a continuous current, then the curve II will represent the counter or motor E. M. F. If our motor is running slowly there will be two or three reversals of current in the time it takes a coil to go from A to B (figure 6), and the product C E will be nearly

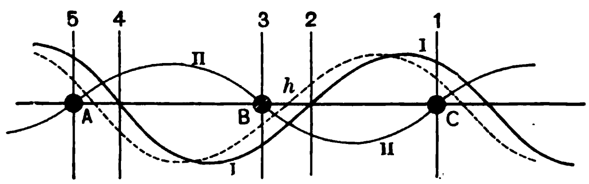

FIG. 5.

zero, the positive and negative parts being almost equal. Whether it is + or — is somewhat a matter of chance, and if it is — from A to B it will very likely be + from B to C. Thus the armature is pushed first in one direction then in the opposite, and there is no definite tendency for it to rotate as a motor. This brings us to our first difficulty, a simple alternating current motor will not start itself. Let us suppose, however, that it has been started by some means and has reached such a speed that in the time of a reversal a coil shall have moved over the distance between two similar poles. We will have the state of things in figure 5, and the armature will continue to rotate. Now the position of the curve II is fixed; we will consider the position of I as determined by the position of the armature coils when the current in them is zero; for instance, if the speed increases a little the curve will advance as shown by the dotted line. The total work transformed is the product of the two curves; from 1 to 2 it is —, from 2 to 3 it is +, from 3 to 4 —, from 4 to 5 +. The result is

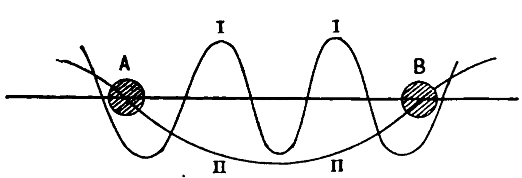

FIG. 6.

— [1 to 2 + 3 to 4] + [2 to 3 + 4 to 5]; part of the time then the machine is working as a dynamo, part of the time as a motor; the difference of the values represented by the brackets gives the mechanical work that is really available. Now while the available work is the difference of these areas, the difference becoming small as the load is decreased, the heating is the *sum* $C^2\,R$ for all the values of the current, and is independent of the position of its curve, as has been pointed out above.

Looking at the figure again we see that from 1 to 2 the armature is pushed forward by the current in the line; from 2 to 3 it is pulled back, since it is acting as a dynamo feeding into the line and can only get the energy to produce the current by decreasing its speed and drawing from its energy of motion. The armature oscillates then, and it is evident that the amount of its oscillation depends on the kind of work it is doing. If it is driving heavy wheels or machinery having considerable inertia it will only have to slow down slightly when it becomes a dynamo. If it is lifting weights the amount of oscillation will be considerable.

It is evident that there is a certain position of the curve I, that will make the available work a maximum. If the motor is doing all of its possible work the curve will take

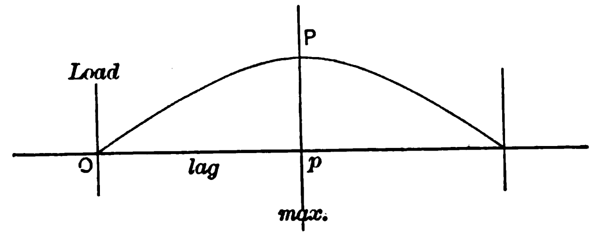

FIG. 7.

up this position; as the load is decreased the speed will increase for an instant until the curve has shifted forward into such a position that the sum of the products — $E\,C$ is equal to the work done. In fact, we can plot a curve representing values of the distance from the point the current curve crosses the axis to the same point when the work is zero corresponding to different loads.

Now the value of this lag, as we will call it, cannot be greater than O P, figure 7, for, although we might extend the curve on the other side, yet a slight increase in our load will cause the armature to fall back, decreasing the available work, and suddenly stop. It is, in fact, in unstable equilibrium.

Suppose we have found the value of the lag that will give us a maximum value of the work, and have calculated this value by the ordinary mathematical methods employed, the real work we can obtain is less than this, for

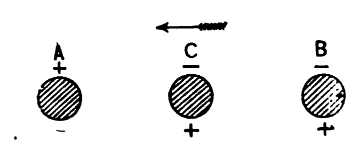

FIG. 8.

the current curve oscillates on both sides of the maximum, supposing we *could* work at the maximum; that is, it is only for a very short time in the best position; so that if we take the sum of the work for a period, it will be less than the calculated maximum. In reality we must work slightly in advance of the maximum, for if we were too near it the curve would fall behind P, and will then be in unstable equilibrium and stop. The practical maximum will then vary according to the amount of the oscillation; that is according to the nature of the work being done.

It seems to me that the possible forms of alternating motors are: (1) ordinary series motor; (2) an alternating dynamo reversed, the field being excited by a continuous current; (3) an alternating dynamo reversed, the field being excited by the alternating current first adjusted by a commutator on the shaft; (4) the arrangement suggested by Professor Thomson, which is described below.

In the first type—a series motor—there is no difficulty in starting; the motor will start of itself. There are these troubles, however: the armature and field must both be

thoroughly laminated to prevent eddy currents; the magnetism of such large masses of iron being rapidly reversed will cause losses unless both field and armature are far from saturation; that is, the mass must be great. Again, Mr. Kapp has shown that to obtain the maximum work we must have, approximately, the counter E. M. F. of the motor equal to the E. M. F. of self-induction—a condition almost impossible to realize in practice. The motor must be governed in some way, as it will not govern itself.

The alternating motor with a field fed from the alternating circuit, the current being commutated, will start itself. I do not know if this has been generally recognized. If, in figure 8, A and B are poles and C one of the armature coils, the effects of the currents will be as shown by the two sets of signs. The effect of either arrangement is to move the armature in the direction of the arrow. When C gets opposite A the commutator changes the relative directions of the currents in C and A, and C is repelled by A and the armature continues to rotate. The maximum work will, I think, be done when the speed is such that a reversal takes place in a distance A to B. The mathematical investigation is difficult, and until I am satisfied as to the assumptions usually made I will not attempt it. We have as an advantage of this type that it will start itself; a disadvantage is that the fields must be carefully laminated, there is loss in reversing them, and there will be for some speeds considerable sparking at the field commutator. I should not imagine, either, that the work obtainable from such a motor would be as great as if its field were fed by continuous currents.

The motor obtained by reversing an ordinary alternating dynamo has advantages and disadvantages. It perfectly regulates itself and the field magnets need not be laminated; that is, it can be made cheaply. It will give a greater output from a given source of current than corresponding machines of either of the types already discussed. Its disadvantages are, that it must be started independently. We must have a continuous current to excite the field, and if a load having any considerable inertia be suddenly applied the motor will stop. This last objection, by the way, will apply to the type of motor previously discussed, provided, as I have supposed, the maximum work is obtainable when the counter E. M. F. has the same period as the applied E. M. F.

Let us see what means we can employ to start the motor and excite the field. We could start by passing the commutated alternating current through the field as in the second type of motor discussed, changing our connections when the proper speed is attained, so that a continuous current from some external source passes through the field and the alternating current is shut off from it. Another way would be to have on the same shaft with our main motor a motor arrangement such as was described by Professor Elihu Thomson in his valuable paper on alternating current phenomena, read before the Institute. With this arrangement we can do more than start the motor. Professor Thomson pointed out that when this auxiliary motor reached a certain speed it would produce a continuous current in the external circuit of its armature. This current could be used to excite the field of the main motor. By properly proportioning the number of coils in the main and auxiliary motors, this continuous current would be produced just when the motor had arrived at its proper speed, and it is evident that we can make this current operate an automatic device to make the circuit of the main motor at this moment. I should imagine, however, that a motor made in this way would be expensive and not particularly efficient.

What seems to me the simplest, cheapest, and most efficient means of running alternating current motors is this: build the motor on the same general plan as the dynamo, with such modifications as the different conditions of working impose, and start it and excite the field magnets from a continuous current circuit, run with our alternating circuit, supplied with current by a dynamo at the central station. If we wish to distribute 500 h. p. our continuous circuit should have a maximum capacity of about 50 h. p. To start the motor we should have the following arrangement: there should be two breaks in our armature circuit, one between the regular brushes of the machine, the other at a commutator for the continuous current. At this second break the two ends of the circuit should be taken to alternate bars of the commutator, the number of bars being such that the direction of the current is reversed every time a coil passes a pole. The alternate bars are normally connected by a metal ring pressed against them by a spring; in this case we will have the normal circuit just as if there were no continuous current commutator. On the motor would be a switch-board that would accomplish the following things: If we wish to start we turn the handle of the switch to a certain position, this will short circuit our regular brushes and by the aid of a couple of levers will drop the continuous circuit brushes on the commutator, at the same time pulling away our metal ring. The motor will then start as a continuous current motor; when it has reached its proper number of revolutions or is above it, turn the handle a little further, the continuous current brushes will be raised, the metal ring will connect the commutator bars, and the alternating circuit will be made and the motor will continue to run and will do work.

Now, I consider that the advantages of this plan are these: It makes the motor simple and cheap to build; it will be more efficient and have a greater output than the other motors that have been discussed; the currents to excite the fields will have to be supplied anyhow, and they cannot be supplied more economically than from the central station; being simpler, there will be less liability of derangement.

The motor described by Professor Thomson, that I mentioned above, consists of field magnets through which the alternating current flows, with an armature not in any way connected with the external source of current, but which has currents induced in it just as if it were the secondary of a transformer. The circuits of all of the armature coils are open excepting one that is in such a position that the current induced in it will be repelled by the pole-pieces. In this form I do not think the motor will be particularly efficient or give any considerable output. It is possible that the principle may be further developed to give a considerable output, but I do not believe that any motor in which the field is fed by alternating currents can be cheaply made, although this is a matter of which I have no experience.

To prevent motors stopping when the load is thrown on it would only be necessary to drive the load from a friction pulley on the shaft of the motor. The pulley should be so adjusted that it will turn just before the motor falls behind the point of its maximum work.

It is possible that all of the plans I have suggested have been tried by the different inventors who are at work on this subject. If a motor of each type that I have mentioned were built and proper experiments were tried upon them, we would—provided we had the ability to interpret and apply our results—have the data necessary to design the best possible machine of each type, and if we build these it should settle the question as to which form will be the best. There is no necessity in building an indefinite number of motors to experiment with. It is too much the custom, if we wish to design a dynamo for instance, to build twenty different ones and see which is best. One machine, with proper experiments and deductions, should put us on the right track.

Dr. Holmes once said that when he had written anything that pleased him it immediately seemed very old indeed. I, with humility, feel much the same way, as if what I had said this evening is so apparent that every one must have known it. I can only hope that some of the suggestions I have made will help the development and final successful application of the alternating current motor.

ELECTRICAL KILLING

BY THOS. D. LOCKWOOD.

OUR friends of the Pulvermacher type, who "make, use, and vend" electric belts, and also the quasi-scientific gentlemen of whom Sir William Snow Harris used to say, with gentle mirth, that their knowledge of electricity was chiefly of the *negative* kind, continue, despite their little disagreements, to write informing us that "Electricity is Life"—this in large type.

What is to become of this beneficient theory in the event of the enactment of statutes in New York state, declaring that electricity is henceforth to be death, is as inscrutable as that other deep and dark mystery—the fate of a member of the British House of Commons after he is named by the Speaker. We learn from the daily and electrical press that the New York Legislature appointed a commission to consider the propriety and advisability of adopting some more humane method of inflicting capital punishment than hanging; and that the commission have recommended electricity as a substitute for the gallows.

This doubtless from the point of view of the commission, is reasonable and laudable. Their good intentions are not to be doubted. Being Americans, they read the newspapers and find out that escaping electricity occasionally kills somebody or something; and they doubtless share the general, but unverified assumption that death by electrical shock is painless.

The use of electricity is recommended by the commission as being more humane. We are left in doubt as to the recipient of the greater degree of humanity. Is it the sheriff, the spectators, or the convict himself? Probably the latter is intended to be the chief beneficiary of the improvement in humanity.

Modes of capital punishment differ widely with races and periods. In France the close shearing knife of Dr. Guillotin is still employed. Spain uses the axe and the garrote. The United States and Great Britain stick to hanging. The Romans had a wide choice of methods; while one very elegant mode utilized by the Greeks, was the method adopted in the case of Socrates—the cup of hemlock. The degree of humanity possessed by any of these modes is an unknown quantity; and there are not wanting scientists and others who maintain that hanging is, and must necessarily be an absolutely painless death. So far as can be ascertained, we have no data gleaned from personal experience which can positively assure us that a death accomplished by the swiftest and most intense application of electricity conceivable, would be altogether painless.

What is the object of the death penalty in the 19th century? Is it for punishment, or is it because it is considered that the only protection for society from further violence is to place the murderer where he cannot possibly commit other crimes? It would seem that both reasons share in the policy of retaining the death penalty for murder. If it were retained only for the safety of society, this could be achieved by a perpetual imprisonment with some statutory or constitutional bar against pardon. If, on the other hand, the idea of retribution be the controlling one, and if it be decided that the death penalty must be retained, must it not also be conceded that the terrors which are inseparable from it, do in effect keep the murder rate down, and deter many from committing murder, who would otherwise be perfectly willing to shed human blood on the slightest provocation? May we not also go a little further and say in view of the above, is it worth while to diminish these terrors by practically telling the murderer, that while we feel it our duty to put him out of the way, we will try to make the passage for him as easy as possible; in fact, absolutely without pain? Why so much solicitude in behalf of the convict?

If painlessness, or a more humane method be all that be desired, or if a superior degree of elegance be thought requisite (and it may be admitted that hanging cannot be regarded as elegant), why not go back to the Roman style of opening the veins of the criminal in a hot bath. Or suppose we adopt the Socratic plan and give our murderers the cup of hemlock? Or what reason can be given in favor of electricity, that does not apply with equal force to a death by the extreme application of chloroform, which would probably be about as humane as any plan can well be.

Electricity lights our streets and houses and propels our street cars; we can communicate both by signs and words through its far-reaching power; we can produce and reproduce forms and figures of marvelous beauty by its action on metals and their solutions; we have caused it to report fires, and to catch burglars; and if we may believe a story which I first read in 1856—and have continued to read at intervals ever since, we can cut down trees with it; but we have not yet pressed a key or a push-button for the deliberate purpose of killing anybody. The recommendation of the New York commission seems to be a cold blooded proposition for the degradation of a noble science; and moreover one which is entirely uncalled for.

Will the electrical engineers of the United States hail with joy this new proposition for the utilization of electricity? Will the *vril* of the Coming Race at last find its realization? Shall we indeed have a trade in execution supplies; and following the lead of the older crafts: "the United States Electrical Execution Association; the American Institute of Electrical Executioners; the Old-Timers Association of Electrical Capital Punishment?" Shall our electrical journals of which we are now so justly proud be obliged to record the invention of new and improved systems for scientific killing! and be filled with advertisements of "complete plants for electrical executions, including dynamo, wires with black insulation, adjustable easy chairs with terminals, commutators and condensers, together with double flexible cord, and all other apparatus required?" And which of us in our clubs and institutes will feel like shaking hands with the expert whose business it is to set up wires, arrange dynamos, fix a criminal properly in his seat, and send the final quietus through his nerves? I for one acknowledge that my flesh would creep at the idea of such a greeting. I hope that the recommendation of the New York state commission will not be adopted.

After carefully considering the subject, it certainly seems to me that electricity is too noble a science to be thus lowered to the most ignoble of uses, and that its votaries can not, should not, and will not endorse the experimental desires of the Albany commission, composed though it be of such distinguished gentlemen as Messrs. Gerry, Hall and Southwick.

The commission in its report, tells us that Dr. Fell, and others, have made certain observations from which they make practical deductions which have aided them in reporting as they have done. Somebody once said "I do not love thee, Dr. Fell," and then professed ignorance as to the reason for his lack of affection. The clue appears now perhaps to be within our grasp.

Let us keep electricity as clean as we can. It is bad enough to have it kill a man once in a while unintentionally as it were; but to cause it to become the instrument of deliberate homicide, even though the killing be legalized, is to my mind an intolerable suggestion.

Illuminating gas is a bad smelling compound, and has a reputation not of the cleanest, but nobody has yet seriously proposed to make it an instrument of capital punishment.

The subject has been handled by Mr. W. D. Howells, in *Harper's Weekly*, and so far as I can make out from his language, he favors the use of electricity. Perhaps this is because he himself is not an electrician, but this does not affect my abhorence of the idea. I can tolerate the idea of having telegraph messages sent to me while I

am traveling on a train, although I don't hanker after that degree of civilization. I am willing to pardon the idiosyncracies of a night telephone operator who calls me up at two in the morning to tell me that it is thirteen below zero; or to give me the inspiring intelligence that "Nicodemus Brown wants his horse," apparently under the impression that I am running a livery stable.

I can condone the horrible howl or the intensified screech of the electric light or power-circuit produced inductively on my telephone line when on a question of life and death I wish to use my telephone; I can even figuratively heap coals of fire on the head of an automatic fire alarm company, which though its thermostats are set at 150, persists in summoning the fire department every time that my cook fries doughnuts; and I can, moreover, by a stern effort of self repression overlook once more the imbecile and Sisiphian electrical yarn about the conduction of electricity from electric light wires down the stream of water proceeding from the nozzle of a fire engine hose, when the said stream impinges upon the said wires, and about the extreme danger of the fireman in consequence thereof. But I do not think I could forgive myself were I to engage in the business of killing by electricity. We must draw the line somewhere, and in the name of electricity in the service of man, let us draw it at capital punishment.

Papers Read Before the National Electric Light Association, Pittsburgh, Feb. 21-23, 1888.

INSULATION AND INSTALLATION OF WIRES AND CONSTRUCTION OF PLANT.

BY PROFESSOR ELIHU THOMSON.

I HAVE been requested to present my views on the above subject, and having recklessly allowed myself in spite of the many other demands upon my time to accept the chairmanship of your committee on the same subject, I have felt it my duty to at least, say enough to provoke a general discussion and interchange of views between others who may have given more special study to the matters in hand. My endeavor, therefore, will not be to arbitrarily lay down any rules but rather to point out directions in which information may be gained and improvements made.

The subject is very extensive in its scope and could not be dealt with except in a very superficial way in the time at our command, and, meanwhile, I feel constrained to state that I make no claim to the possession of any of the qualifications which would be requisite for thorough work on the subject.

In the installation of the electric light or power plant, we first of all find that the conditions vary very widely. Its size, location, the distance covered, or length of circuits, and the climatic effects met with, need to be considered.

Then again the nature of the plant itself, whether arc light, direct incandescent, alternating system with transformers or converters, governs to a large extent the conditions of the installation of the wires and of the plant itself. We may, of course, find in a single station or installation representations of these and other characters of plants, such as medium potential circuits for power transmission alone.

Three or four years ago we should have been required only to take into account simple cases of high potential for arc circuits, and low potential direct currents for incandescent multiple arc circuits, but the range now covered may be considered to be from any potential above 50 volts up to several thousands, and any current strength from about one ampere up to several thousand amperes.

In considering the proper insulation and installing of wires for conveying these potentials and currents we are required to still further extend our field of view, and divide them into aerial, or overhead wires or conductors, and underground systems, and each of these taken in connection with the conductors for indoor distribution to the lamps, motors or other energy uses. We have thus outlined the field which should be covered in dealing with a subject such as we have before us—Insulation and Installation of Wires and Construction of Plant would furnish as a subject material to fill a many paged volume and not by any means exhaust it. May such a work soon be forthcoming.

Concerning the relative merits of overhead conductors and underground conductors, it is pretty generally agreed that except for expense and the difficulties of insulation, and connections from the mains, the underground system would be preferable as avoiding unsightliness, and liability of interference either by leakage, induction, or contacts with the overhead wires. Now to preserve insulation of the lines conveying high potentials, which potentials cannot be avoided if distance is to be covered without conductors of such size as to have a prohibitive cost, is a vital question. It may well be conceded that when the potentials are very low, say 100 to 200 volts, the difficulties of insulation are very slight as compared with those of the use of two or three thousand volts.

It is a notable fact that so far as concerns the placing of overhead wires, particularly the wires of telephone, telegraph, and other such systems and in cases of electric light wires, extreme disregard of systems or orderly direction for such wires is the cause of much of the unsightly appearance presented by them and much of the liability to get out of order. The tendency is also to use very light and easily broken wires for telephonic work, such as may at any time come down upon the necessarily stronger electric light wires, strength being synonymous with efficiency in these latter.

It is thought that there is need of some rules, or enactments to render impossible the mazes of telegraph, telephone, private wires, fire alarms, live wires, dead wires, and electric light wires (which for our purposes may be considered very live wires), such as may be seen in many of our large cities.

Should the wires of all kinds be laid or hung in orderly bundles having a definite direction and only changing that direction by definite angles, such as right angles, in accordance with a prearranged system, I think that much of the objection now existing to the placing of overhead conductors could be eliminated. Add to this a requirement increasing the durability and tenacity demanded for telephone and telegraph wires and their supports, and the damages of leaks and grounds would in a large measure be removed.

Many trials have been made, and considerable progress has resulted therefrom, in the direction of securing an insulating covering for electric wires as may adapt them to the use of high potentials without leakage, and prevent contacts formed by abrasion with other wires. This appears to be one of the most difficult problems in electric engineering. The problem is not so much to find a first-class insulating substance for wire covering, but to find combined therewith, or to combine therewith the qualities of indefinite durability where exposed to the weather, and great toughness and power of resisting cutting or abrasion. For overhead work not only is an excellent insulator capable of withstanding very high potentials without leakage or rupture required, but such property must be retained along with the mechanical properties of hardness and toughness for indefinite periods. Besides the cost must not be too great.

To what extent any quality of insulating wire, or insulating material for out-door use, fulfills this requirement is a matter which it is difficult indeed to determine fully, particularly as a test for durability must necessarily require a long time to complete. Indeed, it would seem that our best guide must be the experience gained in the use of different wires on a large scale under different climate conditions and without extremes of heat and cold more or less great.

Aside from the insulation given to the wire by its covering, considered purely as an insulator, most stress must be laid upon the requirement of resistance to mechanical friction or abrasion, as tending to give immunity from grounds by contact with other wires or with tree branches, roofs, cornices, etc.

Toughness and elasticity of insulation are hence seen to be qualities of high importance.

Whether such mechanical tests as will represent the conditions of actual practice in the use of the wire in relation to abrasion and percussion, bending, etc., which may break through the coating of insulation, can be devised and applied to test wires is somewhat doubtful, though, without doubt, much information may be obtained in the pursuance of such an object.

The retention of the toughness and elasticity for a reasonable period, is, of course, demanded, and it is this retention which in otherwise excellent coverings is often found absent, the effect of exposure being to render the materials brittle and porous.

It has often been proposed to make tests for the insulation resistance of the coverings of certain lengths of any wire, taken as examples representing an average for such wires, under potentials somewhat exceeding that existing under actual use or practice and so to determine the insulating capabilities of different coverings, but it is my opinion that such tests are certainly useful and important, and, in the case of underground wires and cables, indispensable; yet, for overhead work, since most of the length of the wire is exposed to air only, which is a practically perfect insulator, and since the chances of leakage from the lines, arises most from imperfect insulating supports and from accidental contacts with other wires or surfaces, additional tests would in any case, be required to determine the suitability of an insulator for overhead lines. In this connection it may be stated that during thunder storms, overhead wires are subject to violent inductional effects giving rise oftentimes, to the momentary charging of the lines with potentials very far in excess of the potentials of any demands, and capable of breaking through the wire cover-

ing where it may be near, or touch a metal object or wet surface. This breaking through may give rise to a weak spot which will be followed by the dynamo's current itself, if of high potential, and if at the same time other conditions be favorable to a diversion of current.

When overhead wires or pole lines are required to pass through and between branches of trees, a condition not infrequent in many of our towns and cities, considerable difficulty may be found in preserving the insulator of the line, the covering of which is apt to be rubbed off by the tree branches swaying in the wind. Fastening insulators to the branches for support and attachment of the wires is an uncertain remedy, on account of the swaying of the tree taking place in different directions not transverse to the line of wire, so that the wire is strained or detached from its support along with the insulator by the violence of the actions. Many and ingenious are the devices which the over-zealous lineman makes use of to suddenly or gradually and mysteriously lop off the offending limb, when the case is exceptionally critical and permission for the amputation of the offending member cannot be obtained from the conservative citizen whose sidewalk supports the obstacle to the lineman's ambitions.

It is customary to thicken the insulation of the wire at such places as are threatened by abrasion by winding on it a wide band of tough and adhesive tape such as can now be found in the market. If neatly and thoroughly done the insulation of the wire may thus often be preserved under decidedly adverse conditions.

It must be admitted that the insulation of a high potential circuit can never be too good and that, therefore, any measure which may tend to its improvement and preservation is a double advantage, for not only are the dangers of grounds and leaks lessened but the power of the current to do useful work is assisted. A considerable leakage from a high potential circuit means indeed a loss of power or efficiency of the system. For instance, the loss of one-half an ampere of current at a potential of 1,500 volts would represent about one horse-power of current energy lost, costing more than a horse-power at the dynamo pulley to supply such a leak.

This latter consideration is of especial importance in dealing with the lines feeding transformers with alternating currents at high potentials.

With 1,000 volts in the primary circuit it is readily seen that a badly constructed or leakage line might easily cause the loss of a considerable percentage of current, such as would reduce the economy of the system more particularly when running under light loads, at which time it is desirable to secure and to keep up the best possible efficiency.

When wires or cables are to be laid underground their resistance to abrasion is of importance only when they require to be drawn into conduits or sections of conduits, but, when once placed intact, they are not necessarily further subject to mechanical inquiry, as they are generally surrounded by protective casings or tubes.

The total exclusion of moisture and the possession by the wire coverings of a high insulation resistance are requisites of great importance in such work. The difficulties are with low potentials comparatively easy to provide against, but in the case of wires at high electric potentials or pressures, such as arc light or alternating current primary lines, such difficulties are much exaggerated. The least access of moisture, such as may occur by flaws in the insulation, may result in the production of a bad ground; or a slight leak due to some original defect, may so improve itself by the passage of current as to become a bad fault, or a complete connection to earth. It would seem best, in all cases, not to place reliance upon the integrity and perfection of but a single insulating coating or covering for the wire, but to give it say three coatings successively applied, and which are in a measure independent coverings, all of them impervious to moisture and good insulators.

If composed of different materials, the peculiar liabilities to defect of one such coating may possibly be compensated by other qualities in another coating, so that there may be small chance of superposed defects in all coatings alike.

Let but the insulating capacity of each layer or coating be amply good to withstand the potential used, and it is difficult to conceive how trouble could arise from leaks due to defective portions of the covering. First cost is, however, a barrier to the perfection of underground systems, to save which cost, less effective and cheaper structures are often given the place which should be occupied by the more perfect and the more costly.

It is important that in cases in which overhead wires or wires above ground are connected with underground lines, efficient means for carrying inductive discharges to earth be provided, such as is secured by the use of proper lightning arresters; for faults may otherwise be produced in the best underground system of conductors, due to static inductivial discharges existing during thunder storms, at the moments of lightning discharge. These discharges are in overhead lines oft-times quite vigorous, and capable of puncturing moderate thicknesses of insulation. They are not to be confounded with actual passage of lightning strokes to the lines, which of course have an infinitely greater capacity for mischief.

The preservation of the insulation of *inside wiring* is not difficult where the potentials used are low nor is it difficult with the exercise of care and skill in the running of the wires and the selection of suitable courses for them to take, to install simple series lines, such as those for arc lights, which shall be practically exempt from leakage, unless abraded and brought into contact with conducting objects or moist surfaces involving leak to earth.

Unfortunately, owing to lack of skill and judgment and haste in installing, much of the wiring done is not as well done as it should be for the best results.

Distribution of current to groups of incandescent lights upon arc light or other high potential lines should always be undertaken with great care, and it is thought that such work should only be undertaken when exceptionally favorable conditions for avoiding accidental leakage exists; especially should the potential of the line at the dynamo exceed 1,500 volts, or an amount which would sustain 30 arc lamps in series. One of the important elements of safety in such installation is simplicity and ease of inspection of the wiring, and no concealed wires should be used in them.

Concerning the wires which are suitable for indoor work and particularly for high potentials, the endeavor has been to combine moisture proof and fire resisting, or rather incombustible materials in the covering. The difficulty has been to find moisture resisting substances which would not carry fire, and fire resisting or incombustible material which would not carry or absorb moisture. The two properties seem in most cases incompatible. The tendency now is to surround the wire with a first covering of moisture proof material of the nature of rubber, bitumen, resins, etc., and outside of this to place a second layer which will not carry fire.

For house to house and general incandescent lighting where the distance from the station is not too great, the direct low potential system possesses most of the advantages, the difficulties of leakage from the defective insulation being, of course, at a minimum; but where the distances are so great as to make the required outlay for copper in the conductors practically prohibit the extension of the system, a transformer or converter system, if of good design and economy, may be made to yield excellent results. In such cases the high potential primary wires need not enter the building, or when they do may be suitably protected, the house or inside lines being of such low potentials as to be run with ordinary precautions as to leakage. However, the integrity of the system would be changed should a connection or leak form between the primary and secondary wires of the transformer, thus connecting the local or house line with the high potential outside mains. Such a connection might easily exist unsuspected, and would be a constant source of menace or possible danger, not discoverable by the mere tests for grounds as applied to the primary line at the station.

The expedient of securely grounding the secondary or local lines was devised by me to overcome this difficulty. It insures immunity from the risks arising out of possible leak from the primary lines to the house lines, because such leaks are at once detected by the ordinary tests for grounds.

The consideration of the subject of what appliances are the best for the detection and location of leaks or faults in the insulation of conductors when they exist, and whether the ordinary crude methods are adapted to all cases by such detection, would prolong the present paper much beyond its intended limits, and it will have secured its object if it open up an opportunity or give occasion for a free consideration in the interchange of experience and ideas upon the general subject forming its title.

THE UNDERGROUNDING OF ELECTRIC ARC LIGHT WIRES.

BY WELLS W. LEGGETT.

(President of the Brush Electric Light Co., of Detroit, Michigan.)

THIS topic is one of absorbing interest at the present time. Municipal and legislative authority seeks to compel the burying of all the wires without discrimination, and to cast upon the parties interested the burden of finding a practical means to accomplish the end.

The progress of invention in science and art records, infallibly, the contemporaneous public demand. This demand discloses a necessity, and inventive ingenuity suggests the remedy.

Starting from this standpoint we find public wiring began with the telegraph.

In 1753, Marshall, of Paisley, evolved an electric telegraph wherein insulated wires were to be trained on poles, and so Lomond in 1787; Betencourt in the same year; Riezen in 1794; Cavallo in 1795; Salva in 1796; Sommering in 1809; Coxe in 1810, and Sharp in 1813, all had telegraphs, employing from one to twenty-six wires, trained on poles.

At this stage, however, the interesting experiment to which the world lent a helping hand, developed signs of commercial utility, and value. Man's cupidity and selfishness at once antagonizes what he cannot share, and we find the public arrayed in opposition to the use of the highways. Inventive ingenuity

came to the rescue, and in 1816 Ronalds erected and used a telegraph in which some of his wires were placed on poles and *some were buried in the ground.* Tribavillet followed in 1828 with a system employing underground wires, and when Professor Morse, in 1832, brought out his system, he proposed connecting Washington with Baltimore, a distance of 44 miles. To his mind the wire should be insulated and laid in a lead tube in the ground. He constructed his line with great care and at large expense; but only a few miles had been laid when the gradual escape from his line proved his scheme impracticable. He was about to abandon the undertaking when one of his coadjutors, Dr. Page, of the Patent Office, or Professor Henry, of the Smithsonian Institute, said to him: "Take your wire from the ground and train it on poles." The advice was followed and success achieved.

Here then in the incipiency of public wiring is the first recorded failure coupled with its remedy: "Take the wires from the ground and put them on poles."

With underground telegraph and telephone wires the electrical difficulties to overcome are much the same. Moisture must be excluded from the wires. Insulation must be good and induction be reduced to the minimum, especially between adjacent lines. In both, however, leakage from the lines due to imperfect insulation may be compensated within limits by additional battery force. The battery acts like a pump sending water through a leaky pipe, the water may all escape before reaching the discharge end—but with a more powerful pump, while increase of pressure will cause greater escape through leakage, one may succeed in discharging a limited quantity through the end of the pipe and so accomplish the purpose sought.

For this reason underground telegraph and telephone wires may be operated with a measure of success.

In most of our cities all telegraph wires might be led to a certain point from which the wires of all systems could by one underground conduit be led to a central station or stations, and thence back through the same conduit; and where the wires are numerous might warrant the expense.

With telephone companies whose subscribers are in all parts of the city, the requirements that each wire should be conveyed underground would involve an outlay for conduits wholly prohibitive.

For direct service incandescent lighting the required conductors are so large that to train them upon poles or to train an equivalent capacity—in smaller wires on poles—would involve outlay and annoyance exceeding that required to underground the conductors.

So again the resistance of the conductors to the flow of the current is exceedingly slight; it might be compared to the pouring of water from a pitcher through a six inch pipe—its course of least resistance lies right forward through the pipe, and there is little tendency for it to seek an exit through any other restricted channel.

In comparison with it the arc light current might be likened to a large hose with a small nozzle, through which water is being forced with a powerful pump—the tension is very great, and if so much as a pin-hole exists in the hose, water will squirt therefrom, and quickly enlarge the orifice to a fatal rent.

From the fact, therefore, that telegraph and telephone, and incandescent electric light wires may be trained underground with success, by no means does it follow that the same is true of arc light wires.

It is an undoubted fact that to successfully underground electric arc light wires involves simply and solely a question of expense. But expense may be of the very essence of the inquiry, for if the expense is out of proportion to the revenue that can be derived from the service, expense alone prohibits the outlay and determines it to be impracticable. Expenditure of money is alone required to tunnel the Dover Straits, and yet French and English capitalists have pronounced it wholly impracticable, as the returns could not warrant the investment. So it is with electric arc light wires; an efficient system, so far as inventive ingenuity has yet presented any plan, involves an expenditure wholly prohibitive, and for that reason alone is impracticable.

Electric arc lights may be employed successfully, trained in the air on poles, and an underground system is practicable which can reproduce the same conditions. Let us examine these conditions. All substances are conductors, as copper, iron, lead, rubber, glass, dry air. Some substances are such poor conductors that, in comparison with those that are better, we call them non-conductors, and the greatest available non-conductor is dry air. We use these poor or non-conductors, such as rubber, glass, paraffine, wood and dry air as insulators, and we find dry air to be our most perfect insulator. Dry air is a better insulator than rubber: if, therefore, in dry air two rubber covered wires cross in close proximity to each other, the induction is greater between them than would be the case if both wires were bare. But air is usually laden with moisture, and water, charged as it is with the mineral salts and acids of the atmosphere, is a good conductor. We therefore coat our line wires with an insulating material, to shield them from direct contact with moist surfaces or other good conductors, and so reduce in amount the current which is always escaping by connection to the ground, and which varies in direct proportion to the conducting property of the intermediate medium.

Where our insulated wires are trained on poles, we have at the rate of thirty poles to the mile, thirty points at which a small amount of current may and always does seep off to the ground.

Now let us put an insulated cable in a conduit in the ground. The conditions are all changed in the most aggravating manner. Instead of comparatively dry air, the air is clammy and heavily laden with moisture, instead of a mass of surrounding air as on the poles, the envelop of air is, at best, but an inch more or less in thickness. Instead of resting at thirty points in a mile on glass supports, connected to dry non-conducting wooden poles to make the passage to the ground as much obstructed as possible, the line touches the conduit at say two or three points in the space of every foot or at say ten thousand points in a mile, and the conduit itself, a much better conductor than glass or dry wood, is all that separates it from the moist earth.

The bearings at which the current may seep away have been multiplied from thirty contacts to ten thousand contacts per mile, while the conductivity of the medium at each point has been greatly enhanced. A regulating arched subway has been suggested, and approaches most nearly to a successful plan, but only a state or city could stand the necessary outlay. A subway of this character, four feet wide and eight feet high for Chestnut street alone, in Philadelphia, was estimated would cost the city $1,500,000. After completion such a subway would have to be supplied with forced ventilation to keep it dry. If then the insulated wires could be supported so as to touch at but thirty points to the mile, the conditions of exterior wire training on poles would be fairly approximated.

The question is frequently asked, if telephone and telegraph wires can be undergrounded, why cannot arc wires. The reason is plain, seepage or escape can be supplied in the former by additional battery power, but an arc light generator is a queer specimen of mechanics.

It starts a mild current, and this passing back around its field magnets, builds them up; the increased magnetism induces greater impulses in the bobbins of the armature; the current thus increased continues to pass through the line and back around the field magnets until the current has reached its maximum. It is, therefore, apparent that anything which seeps the current from the line, not only steals the quantity which has escaped, but prevents just so much current from passing back around the field magnets, and to that extent robs the machine of its capacity to generate a current. These machines are capable of taking care of the same amount of loss at the insulators in the pole and line system, but when this is multiplied many times as in an underground conduit, it is so robbed of its power to recuperate that the resulting lights are necessarily reduced in number and are weakly and sickly.

Operations looking to the undergrounding of arc light wires have been prosecuted on a large scale at New York, Brooklyn, Chicago, Philadelphia, and Washington.

Notwithstanding all reports to the contrary, I find that at New York, although the subway commission has expended vast sums of money and has succeeded in burying certain telephone and telegraph wires, no arc light line has up to this time been buried in New York city, and this is fully corroborated by the report of the board of electrical control of January 6th, 1888.

At Brooklyn, New York, the board of commissioners of electrical subways instituted thorough investigation of this subject in 1886, and in its report of December 30, 1886, says:

"With regard to electric light conductors this board has found no device which would, with certainty in its opinion, enable the wires carrying arc light currents to be safely and successfully operated in the same conduit with telephone and telegraph conductors without disturbance or injury to the latter.

"But the board desires to say, emphatically, that those fluent critics who talk of putting electric light conductors underground, making no distinctions between arc lights and incandescent lights or between the arc lights of different systems, are ignorant of the alphabet of the subject."

The president of the board visited all the principal cities in Great Britain and Europe; he found no arc light wires underground, and although a few years since such wires were trained in the Paris sewers, they have been removed and no arc light wires are now allowed therein.

The Brooklyn commission made another report, December 15, 1887, and on this topic say:

"As was fully explained in the last report, the subject of underground conduits for arc currents is the one which presents the most numerous and novel difficulties.

"Since it has been impossible for Brooklyn to take the lead in the experimental solution of these, the only remaining course was to watch carefully the progress of experiments in other cities. This has been done, both by correspondence and by personal visits of members of the board. The principal cities in which experiments of this kind have been in progress are New York, Chicago, Philadelphia, Baltimore and Washington. In one or another of these, several systems which were regarded with favor a year ago,

have since developed defects or even come to entire failure. It cannot be said that any system has yet been completely proven to be permanently satisfactory.

"There are one or two, however, which promise well, and this board awaits with attentive interest their further trial, regretting only its inability, through the cause already specified, to co-operate in the experimental investigation of the different and delicate questions involved."

There are no arc light wires underground up to this time in Brooklyn.

At Washington, in 1884, cables were laid in F street, from 9th to 15th. In a few months, it was necessary to dig up a few of the same. Later, there was much more trouble, and it was all taken up and relaid. About one year after the first laying, it was wholly abandoned, because they could not make it work.

In 1885, they laid cables on Pennsylvania avenue, from Ninth to First streets, and imported an expert from Antwerp to lay them.

Twelve cables were laid in solid cement, and no expense spared to insure success. They proved an utter failure. The avenue was dug up many times. The wires were in September, 1887, mostly out of service, and the remainder were in such bad shape that they would require constant repairing or have to be abandoned.

An officer of the Washington company, writes me under date of September 12th, 1887: "We have many committees coming here to see what we have accomplished, as they have heard that we have met with great success, and so forth. We will say to you, that our experience, after the outlay of many thousand dollars, is this: have nothing to do with underground cables for arc lighting if you can possibly avoid it. Many will tell you that it is perfectly practicable; look out for such parties: they are probably interested directly or indirectly in cables. There is a big lobby in that branch of business. There is no city or town in the world where a cable has been made to work two years that has been subjected to 2,000 volts of pressure.

This Washington company is using lead covered cables with success, for incandescent work; but as to the undergrounding of arc light wires, confirmed as late as February 7th, 1888, they report that out of 14 miles of arc light cable, in fourteen different circuits, all have proved total failures, and have been abandoned except a very small amount.

At Philadelphia, elaborate experiments have been prosecuted. All kinds of cables have been employed, and a great variety of conduits; great trouble has been experienced. The systems largely employed were such having ducts through which the cables were drawn—in most cases the insulating compound rapidly deteriorated and became useless—in others it would be rotted and become water soaked. Where lead covered cables were used in conduits where creosote was employed, the effect was to rapidly oxidize the lead covering and disintegrate the same. It was found that gas could not be kept from the ducts although apparently gas tight—many explosions followed. Recourse was then had to ventilation by lamp posts, but the trouble was not corrected. After several explosions in one system, in which persons and property were injured, a power fan was adjusted to force air through the conduit, deeming it better to do so than to draw the air through, which might simultaneously draw in gas. When shortly afterwards the lighting company was congratulating itself that it had overcome the difficulty, a tremendous explosion ensued, extending for a long distance, ripped up the street, and broke a large plate glass window. That entire system of lights had to be abandoned. It was some six months ago determined by the manager that as a result of experience, no conduit would suffice for arc light wires in which there were open ducts, and that success lay in the employment of lead covered cables buried solid. This plan, suggested by the city electricians, was tried and success seemed assured, but they now report the experiment unsuccessful. The section buried is not great, but three bad grounds have recently developed. Two were repaired, but the third necessitated the temporary cutting out of a part of the line and the training of wires on poles until the earth may thaw and enable access to be had to the wires.

The various companies of Philadelphia are at a loss what to try next. At this point, I would note that these demands for a system for arc light wires have greatly stimulated inventive ingenuity, but as yet without success.

Out of 72 patents that have been issued in this line, 53 of them have emanated from Philadelphia, New York, Boston, Brooklyn, Wilmington, Camden and Washington—all being in the immediate vicinity of the places where the operations were being conducted. The others were mostly from the general vicinity of Chicago.

Now, as to Chicago—much has been said of its system—a visit to Chicago satisfied me that its electric arc light industry was being strangled. A few blocks in the immediate heart of the city were using electric light very lavishly, but the area lighted is scarcely a half mile square. This small area is served from no less than nine separate plants, formerly belonging to as many companies, but now consolidated into one.

A letter under date of September 20th, from an officer of the Consolidated company, explains the situation there. He says: "We have had an enormous amount of trouble with our underground arc light circuits, averaging, I would say, for the last three months, one burn out every day. The expense of reconstruction and the losses in rebates have been enormous, and the annoyance to our customers more damaging still. Commencing in April last, we bought out some nine arc light plants in Chicago, and have proceeded to concentrate them into four main stations, burning about 1,100 lights; their owners had all been using underground conductors composed for the most part of okonite, kerite, Callender and underwriters' wire. Everyone of these insulators has failed constantly, the only thing that has held up at all is lead covered cable, and we have been driven to the great expense of taking out every foot of the old construction and substitute new lead covered cables throughout. This work is not yet done. Our people are confident that a large business awaits us here, but its development will depend entirely upon service. These lead circuits may fail much sooner than is anticipated, and it is almost certain that we shall be compelled to reduce the number of lights upon a circuit—a very difficult matter in a city like Chicago. Our conduit space is already filled along the main routes, and additional conduits will be necessary. The constant tearing up of the pavements for all kinds of purposes, makes our street department very unwilling to grant permits for laying additional conduits, and several times they have been refused altogether. I would say here, that arc light business in Chicago has developed entirely since the passage of the underground ordinance of 1881—the result has been the multiplication of small isolated plants and the formation of the nine small central station plants bought out by this company. None of these plants made any money. It was impossible for them to do so, operating underground and upon so small a scale. No streets have ever been lighted by electricity here, in fact the whole industry is in a very backward condition, and is likely to remain so, except in the most densely crowded portion of the city, unless some arrangement can be made with the city authorities for overhead wires. The city is trying an experiment of its own in lighting Chicago river, which will, I am confident, demonstrate the truth of the foregoing statement; and in the course of a year I hope that our city fathers will permit overhead lines, in many places where public convenience demands electric lights while underground construction would forbid it."

At Milwaukee, Wisconsin, three systems have been tried and abandoned—*i. e.*, a wooden truck plan, and tarred iron pipe and grooved wood. A fourth consisting of tile conduits with a heavily insulated but not lead covered cable had recently been introduced and is now being tested. The company doubts whether it will stand the trying spring season.

At Detroit, the Thomson-Houston Co. employed a cable of the most expensive and approved character in the Dorsett conduit, and the mechanical work was of the best quality.

While the cable was new the results were fair, though loss by seepage rendered it impossible to produce normal lights.

It was found impossible to operate telephone wires in the same or adjacent pipes. The company soon abandoned the system, and when its cable was removed it was found the insulation had so rotted or softened that considerable lengths of the wire in many places was stripped bare.

With the alternating system some wires have been undergrounded in Springfield, Mass., and in Denver, Colorado, and a small amount in Pittsburgh, but the voltage is only half that of the arc light systems, and even with this low voltage the lead covered cables have not been in use long enough to determine the question of their success.

The difficulty from explosions of gas has been met with many times at Chicago, New York, and elsewhere, as well as at Philadelphia, and seems insurmountable where gas is employed. At New York, men have been suffocated in the man-holes, and in the Western Union building the escape of gas from their conduits has been almost unbearable. At Detroit an explosion took place in October last, in the middle of the night in a fire-alarm conduit with close man-holes, and in which no wire had ever yet been placed. It doubtless occurred through the admixture of illuminating gas and sewer gas or other exhalations in proportions to explode spontaneously. The man-hole cover was thrown high into the air, the street torn up and the paving blocks scattered over a distance of eighty feet or more.

The problem of undergrounding arc light wires is by no means solved, but appears to-day to be further than ever from solution, owing to the utter failure of systems which apparently had all the elements to insure success. In this emergency municipal bodies must suit their action to the facts. To legislate arc light wires beneath the ground when no practical system is presented for accomplishing that end, is actually and literally to bury the system.

When a city is so sanguine of the soundness of its judgment, the remedy would seem to be for the city to provide conduits and the necessary cables, guarantee their success, and then compel lighting companies to rent their lines at a proper figure, or failing so to do to quit the field.

Summary action on any other basis is incompatible with that justice and equity, which it is the inherent right of every person

to demand and receive. Any other course is to discourage enterprise, and to ruthlessly impair or destroy capital invested in good faith.

The difficulty usually met with is a peculiar and unreasonable one. Municipal and legislative bodies view with suspicion the lighting companies, their officers, stockholders, and everybody connected with them. It seems to be assumed that because the companies make a certain showing of facts, the facts must necessarily be exactly the contrary, and they legislate accordingly. Thus, at Detroit, in opposition to letters produced by the lighting company, alleging repeated trials and failures at Washington, Philadelphia and Chicago, the then mayor, unquestionably in good faith, reported to the council, as the result of his personal investigation upon the spot, that no electric light wires had ever been buried in the city of Washington, a most glaring error, yet this was followed by a report of the committee, and unanimously adopted by the council, that underground systems of electric arc light wires were entirely practicable and were in successful use at Washington, New York and Philadelphia. At Cleveland recently, the strongest argument in the underground struggle advanced by the city, was that the wires of the Thomson-Houston Co., of Detroit, were operating underground in the Dorsett systems, whereas not a foot of arc light wire is underground in Detroit. To combat this unreasonable and unreasoning prejudice, the question whether any system yet discovered is practical and sufficient for the purpose, should be thoroughly and exhaustively examined, and an elaborate report made and published with full data upon which the conclusions are reached; this should be done by a board of competent and eminent men of national repute entirely disconnected from the electrical business, such as could be gathered from the scientific chairs of our largest colleges and polytechnic institutes, and it would rest with the interested companies of this association to contribute from their own funds or to influence the necessary contribution by the councils of their respective cities to pay the necessary expenses of such an inquiry.

UNDERGROUND CONDUCTORS FOR ELECTRIC CURRENTS.

BY JESSE M. SMITH.

THE question of underground conductors of electric currents is one which every person interested in electricity should study fairly and with a predetermination of solving.

It is not purely an electrical question, in fact, the electrical part of it is far overbalanced by the mechanical.

There is no difficulty in finding an excellent insulating material, but the difficulty lies in the holding of this insulator on the conductor.

Many substances are good insulators in dry places; some are good under water; some in damp places; and a few will stand acid and alkaline fumes and the ravages of sewer and illuminating gas, but how many will insulate under all these conditions and in addition be substantial enough to withstand the mechanical injuries to which they are exposed when buried under the streets of our large cities?

A few years ago wire wound around with a little cotton soaked in paraffine was thought sufficiently insulated until the insurance companies had a few losses, due of course to electricity, and then we had underwriters' wire.

The name of this wire has sold hundreds of tons of it, but that does not prevent its grounding a whole system when it comes in contact with the least moisture.

It, however, marks one state in the evolution of the perfect insulation.

There seems to be comparatively little difficulty in making a cable that will carry high potential currents when constantly submerged.

The conditions are substantially the same at all times. There are no alternate changes of moisture and dryness: no great changes of temperature; and very little of the destructive action of gases.

The conditions of the underground conductor are very different.

Here the conductor is dry, then wet; it is frozen, and again thawed; it is attacked by sewer gas, and the corroding action of the water leaching through the accumulated filth of the street; it is subject to the destructive action of the leaking gas and steam pipes, and finally, but not the less surely, to the ruthless "ditch digger."

These are certainly formidable obstacles, but a number of them have already been overcome, and the others must be.

Public opinion says the wires of all kinds must go underground, and electricians, engineers, and capitalists must find the means of doing it.

The question resolves itself into three parts.

1st. The electrical insulation of the conductor.

2d. The protection of the insulator from the effects of moisture and corrosion.

3d. The protection of both from mechanical injury.

The question of electrical insulation seems to me to be solved by at least six of the standard compounds now in daily use

The second part of the question is the most serious.

If any of the standard insulations can be enclosed so as to be protected from direct contact with moisture their chances of life are certainly improved, but if they can be hermetically sealed, they should be practically indestructible provided the casing is indestructible.

We single out as among the best materials from which to form such a casing—iron and lead.

Cast iron, underground, will last a great number of years, as shown by gas and water pipes, but it cannot be obtained in lengths much over 13 feet, and the numerous joints multiply the chances of leakage. The conductors must of necessity be drawn into the pipe after it is in place.

The conductor must be considerably smaller than the pipe, and therefore moisture will creep in between the two.

Wrought iron pipe if well coated with asphalt or some similar substance will last a long time.

It may be had in longer lengths than the cast pipe, and the joints are more easily and surely made.

If screw threaded joints are used the conductors must be drawn in, with the same objections as with the cast pipes. If the lengths of pipe are prepared with the conductors in them before laying, joints must be made in the conductor as well as in the casing, at short intervals.

Joints are the bane of electrical construction. From the dynamo to the lamp and return the current is forced to pass joints which frequently offer more resistance than 1,000 feet of wire.

At these joints the insulation, instead of being better than at other points of the conductor, is generally worse, and oftentimes none at all is found.

It is not strange that the current should seek an easier path home, and take to ground, rather than be forced through the accumulated resistance of all these joints.

I will venture to say that of all the failures of underground conductors, 90 per cent. are directly traceable to the joints, and for that reason it is desirable to have as few as possible.

The conductor may be obtained in, practically, any length, and the insulation may be put on continuously, but in order to have a continuous casing it must be formed of some soft and ductile metal which can be closed about the insulated conductor in the course of its manufacture.

Lead seems to be the only commercial metal that will meet these conditions, and there are objections even to it.

Lead is soft and easily punctured and offers little resistance to crushing or bending, and is attacked by rats.

On the other hand, the corrosive action of the earth has little effect upon it; while its pliable nature permits of its use in many places where iron pipe could not be used.

Being soft and ductile it can be brought into such close contact with the insulation as to prevent or at least retard the creeping of moisture between the insulation and casing.

It seems to me, therefore, that lead casing offers more advantages and less objection than any other form of protection to insulation as yet open to our use.

The third part of the question, viz.: the mechanical protection of the casing, and hence the conductor, is not so difficult a matter.

If an iron casing is used little or no protection is needed.

The pipe is strong enough in itself to withstand any ordinary abuse.

If lead is used, however, it should be kept from contact with sharp stones, bits of glass or metal, and have something about it to warn the "ditch-digger" before he strikes it with a pick.

An ordinary square wooden box is oftentimes sufficient.

If it does rot away it leaves a bed of soft mould.

The box may be made of white oak well creosoted, in which case it will last until the next generation finds something better.

If the underground conductor is to come into practical every-day use, it must be so constructed that it may be tapped at any point, as readily and with as much certainty as a water main is now tapped.

How many miles of lead water pipes are now buried in our streets?

They are not protected by boxes or conduits of any kind, yet it is comparatively rare that we hear of their failure.

If such pipes filled with water can be laid in the earth without protection, why can not a lead pipe filled solid full with copper and insulation be buried with even more success?

Good workmen can certainly be found who can cut a conductor, splice in a branch and solder it, replace the insulation, and finally wipe a joint on the lead casing with as much ease and certainty as a plumber can make a joint in a lead water pipe and have it stand 100 pounds pressure,

In a general system of distribution there are two classes of conductors, one which we may call through mains or feeders, and another service mains.

A number of through mains may be bunched together in a cable, under one casing, where they run in the same direction for considerable distances. These may be drawn into conduits, as they are not to be used between the main distributing points.

Service mains must, however, be so constructed that they may be tapped at any point, and that very readily.

Large sums of money have been spent in New York and elsewhere on conduits for electric conductors.

Are conduits necessary or desirable in electric lighting? Service wires are of no use whatever if placed within them unless man-holes are provided at every 100 feet. Through mains are certainly well protected when drawn into conduits, but at a great expense. No engineer would, I think, at this day, risk putting a conductor in any conduit which he would not be willing to trust under water or laid directly in the earth.

Why not take one half of the money which these conduits cost and use it in buying thicker lead casing and bury the conductor in the ground or in a common wooden box?

The underground conductor of the future, I believe, will be formed with a core of copper cable, thoroughly insulated by any of the standard and well tried compounds; protected by close fitting lead casing, thick enough to resist mechanical injury, and buried in the earth in such a manner that it may be tapped at any point. But where is the money coming from to pay for these conductors?

Whenever electric light plants are installed in a thoroughly mechanical and substantial manner, with due regard to the most economical production of power, so that the electric light is perfectly reliable and obtains public confidence, then the money will be forthcoming.

When capital enough is invested in electric lighting to enable it to cope with the vast sums which have been accumulating these many years in the gas industry, then we shall see our dynamos driven by the waste heat and refuse products of the gas works, and our houses will be heated by gas and lighted by electricity.

THE RELATION OF ELECTRIC LIGHTING TO FIRE INSURANCE.

BY S. E. BARTON.

In considering the relation between electric light and fire insurance interests, I must confine myself mainly to the situation in New England, because I am familiar with what has been and is now being done there, and I am quite as unfamiliar, except in a general way, with the relations that exist between the two interests outside of that small but lively quarter of our country.

In order that you who live away from New England may better understand what I may say as I proceed, it will be well for me to tell you briefly what kind of an insurance organization we have here.

The New England Insurance Exchange, which exercises a modest control over a part of the fire insurance matters within that territory (with the exception of the city of Boston and state of New Hampshire), is a body composed of the special agents, adjusters, traveling men or so-called "field-men," representing the various Stock Fire Insurance companies doing business there—some one hundred and fifty in number. These men mostly have their headquarters in Boston, which is verily a "Hub" in that respect. They are constantly skirmishing over the territory, individually or in squads of two or more, adjusting losses, and occasionally, through the co-operation of their local agents in the towns and cities, stealing good risks from each other or from some other competitor; but every Saturday finds a large majority of them back in Boston, where they convene in regular session and consider, with legislative dignity, any matter of common interest—electric lights included. They swap experience, swap yarns, swap anything for something better; consequently, they are a body of wonderful unanimity in any cause that promises common good to themselves and justice and fairness to others. They say to electric lights "burn," after our inspector has approved the manner in which you are installed and maintained; and as a consequence there are in New England to-day, not including Boston and New Hampshire, 13,944 arc and 157,848 incandescent lamps radiating their beautiful bright light where the feeble flicker of the gas jet and kerosene lamp could not penetrate. So concerted is the action of these men, that were they, by reason of any necessity, compelled to say that electric lights shall not burn, comparative darkness would once more reign supreme in that fair land; but while they continue to count upon their fingers the yearly fires caused by this modern illuminant, I think I can safely assure you that their dreaded power of extinguishment will not be exercised. I have made exceptions of the city of Boston and state of New Hampshire, the reasons for which are these: The former, in its fire insurance matters, is supervised by a similar organization to ours, known as the "Boston Underwriters' Union," which handles electric lights in the same manner as our exchange. The latter, through antagonistic and unfair legislation over two years ago, caused the absolute retirement from that state of every outside Stock Fire Insurance company, and they now manage that business themselves. By what light they work, we know not, but judging from their sad experiences of the past year, we are led to believe that they work by the unholy light of their own wicked ways.

I have described the character of our exchange principally to show the difference between it and most of the insurance organizations of our country, which are generally composed of officers of companies, or local or general agents in the large cities, between whom, by reason of their greater competitive relations, there exists a less amiable desire to harmoniously and successfully devise and carry out methods of improvement and mutual good. In the first year of our existence, some five years ago, we realized, after having paid considerable sums for losses caused by electric lights, that our interest demanded the inspection of all such apparatus by some person selected by ourselves, if we were to continue granting permits for the lights without charge. We were a year or two, in a sort of experimental way, in getting settled down to a perfect system of inspection, but the result of the last two years immediately preceding 1887, showed us, for the labor we had undertaken, a loss of less than eight thousand dollars from electric lighting in our territory. We had by that time not only given up all thought of making an extra charge for a permit to use your lights, as we do in many cases for kerosene oil, and in some instances for gas, but we were fast beginning to show our preference for your illuminant by granting reductions in our rates of premium. The year 1887 has shown us a loss record from your lights something less than any previous year, notwithstanding the great increase in your installations, and the spirit of recognition of your superiority in point of safety, has steadily gained ground, until, I am happy to predict, that before another month has passed the New England Insurance Exchange will have announced its favor in the form of a schedule of reduced rates which it purposes to make on certain classes of risks where the exclusive use of electric lights is guaranteed. I think that in this respect we will have fairly taken the lead.

A proposition to this end was made by the electric light committee of our exchange a year ago, but while we had for two years previous made an occasional reduction in rates, and have done so more generally during the past year, the time has not seemed ripe until now for an open announcement to that effect.

This feeling of preference for electric lights has been very gradual in gaining ground with us, and has reached a general recognition from the fact that the fires from that source have been few in number and the losses small in amount; and this favorable result has most assuredly been due to our perfect system of inspection. In this claim I am supported by the greatly increased number of fires that are reported as occurring in sections where insurance inspection does not prevail.

That there are in your method of lighting many inherent possibilities of causing combustion and loss of property thereby, I need not claim, because none of you would for a moment deny it; but what I do claim, and mean to persist in maintaining, is that there is no reasonable excuse for any fire to be caused by your apparatus, except in very rare cases where some unexpected and unavoidable accident may occur. It is quite possible for you to reduce the fire hazard of your system to the very lowest degree. It is quite *impossible* to do so with any other means of artificial lighting.

How can any care or control be exercised over the promiscuous use of kerosene lamps, while men, women and children, are handling them? What can prevent the innocent but agile cat from upsetting the lamp carelessly left in its path, as it is not infrequently accused of doing? Surely no insurance inspector, even with *his* ubiquitous habits, could prevent such catastrophes.

While greater care and a system of inspection could prevent many explosions in the gas system, they could not prevent combustible material from coming in contact with the open flame, neither in the dwelling, the store, nor the workshop; nor could they prevent an accidental escape of gas through a leak, or a burner carelessly left open, and in that event no amount of cautionary rules could deter the innocent occupants of the premises from going in search of the leak with an open light in their hands.

While our policies distinctly exclude damage caused by explosion, unless fire ensues, and then only cover the damage *by fire*, there is usually fire enough to "ring us in," and the drawing of the line between the explosion and the fire is usually disastrous to us.

Therefore I hold that, while no possible human foresight can prevent fires from the old methods of lighting, it is not only possible, but quite an easy matter, to prevent them in your case, if you set about it rightly.

If I were to presume to offer advice in the matter, it would be this: Where insurance inspection is already being practiced, combine among yourselves and support it by paying whatever is reasonable for carrying on the work in an intelligent and economical manner; also by helping them improve their rules and requirements from time to time as your experience develops new means of safety.

Where such work is *not* being performed, get together in the same manner, those of you who are operating in that field, and ask the insurance men to appoint an inspector; then submit your work to him, conform cheerfully to his reasonable requirements, and go to the public with his approval. The approval by insurance companies of any lighting, heating or power device is *necessary*. The public *wants* light, heat and power, but it *must have*

insurance, for on that the great commercial fabric of to-day depends for solidity.

By such inspection you will bring the fire hazard down to the minimum; you will largely increase the growing confidence of the public in your lights; you will rapidly clear away any lingering prejudice with insurance men against you, and in place of opposition that you may now occasionally meet with from them, you will readily obtain their fullest endorsement; more than that even, you will doubtless receive positive encouragement from them in the way of concessions in rates, in many cases.

The two interests should harmonize and work together to the greatest degree. You have in your system of artificial lighting great possibilities of reducing the enormous fire waste considerably; while we have, through our endorsement and encouragement, the power to largely increase your development; and the two together can give mankind more light and better light, and they need it.

I do not hold that you are deficient in any degree as to what does and what does not ensure safety in your work, but I think that you will agree that in the construction and maintenance of your equipment you are sometimes obliged to depend upon those who are not so proficient in their calling as they might be. The good insurance inspector, who gleans his knowledge and experience from all, helps you to educate and improve in usefulness those employed to whom you entrust your work. I refer particularly to the construction and dynamo men, and the trimmer —to the latter more particularly. If this functionary had possessed a knowledge of the possibilities of fire from the arc lamp, the losses from electric lighting in New England last year would have been too inconsiderable for mention.

Right here I wish to speak of the habit that sometimes possesses local companies—that of hiring inexperienced help because it is cheap. It is false economy, I think.

Competition, which is very great among you, drives you in some cases to lowering the standard of your material and work. It compels you to figure in every possible way to get a job. Nine of you may be honestly inclined to maintain the highest degree of perfection, but the tenth one outbids you all by figuring for cheap work. Careful and conscientious insurance inspection brings him up to the rack, or shuts him out, and we all profit thereby.

The question of insulation was referred to in a pointed and timely manner by our friend Haskins, a year ago, and his suggestions seem to have taken root in the east. Insulated wire is now the rule, rather than the exception, in those places where insulation is most needed, and painted wire has "lost its grip." The difference in the cost is too slight, and in point of efficiency and economy too great to allow the reform to languish.

The location of central stations seems to be receiving merited attention, but not to that extent which the good of the profession demands. In the past, the practice has been to secure power, especially in the smaller places, where it could be had the cheapest. without regard to permanency and surroundings. The result has been that you have gone into cramped quarters, with hazardous occupations on all sides, above and below you. You have got power by using boilers already being worked well up to the limit of safety, or you have set other boilers in the limited space at your disposal.

There have been fires and losses charged to you which you might have escaped by locating more wisely, and as a consequence, too many insurance men now look upon the electric light station as one of the hazardous risks.

Locate by yourselves as much as possible; build after modern fashions; do not spare brick walls and cement floors where they will add to your safety, and then you will get lower rates from Stock Fire Insurance companies or our "Mutual" friend, Woodbury, will provide for you.

There are in New England, as many of you are aware, a dozen or more good, strong Mutual Fire Insurance companies, known as the "Manufacturers' Mutuals." They confine their acceptances of risks to the largest and best manufacturing properties in New England and the middle states, and, to a limited extent, in the southern states and Dominion of Canada. Mr. C. J. H. Woodbury is one of the vice-presidents of the largest of these Mutual companies, and the recognized expert authority for them all. About five hundred of the large manufactories insured by them are lighted by electricity, either arc or incandescent, and very largely isolated plants. They have received the inspection of Mr. Woodbury, and the greater part of those in New England, that of Inspector Brophy, also. I take pleasure in quoting from a letter on the subject recently received by me from Mr. Woodbury. He says:—

"When electric lighting was first introduced it was the cause of a great many fires, there having been twenty-three fires from this source in the sixty-one mills using it in 1881 and 1882. By April, 1882, all the electric lighting plants in property which was insured by the Mutuals had been changed to conform to the rules for installation which I had prepared in December of the previous year, and since that time *we have not had a single fire from electric illumination. I do not know of* any fires caused by electric lights which did not owe their origin to a disregard of principles laid down in these rules as essential for safety."

I think that statement bears me out in my assumption as to the almost entire immunity from fires due to artificial lighting that is attainable by the use of your methods, and I ask no better support.

Mr. Ridlon has advanced some excellent ideas looking to better work, in point of safety, in construction and maintenance, —that of examination for fitness and qualification of the men who do this work, and the granting of certificates to them if found competent, the same as is done in the case of steam engineers. He would have the board of examiners composed of electrical and insurance experts. The absolutely impartial inspector is still needed to see that the "*tenth man*," of whom I have previously spoken, does not prosecute his nefarious work without a certificate; also to see that those *who hold certificates* are not intrusting their work to cheap men *who don't hold them*, or that the guileless trimmer is not falling into the habit of leaving the bottom off his arc lamps.

I would not occupy your time with technical suggestions, if, indeed, I had any to offer, because they had better be left to printed rules and inspectors; but it may interest you to know to what extent your business has prospered in New England.

The following figures are taken from our inspection records, and are probably about right. They are *inclusive* of Boston but *exclusive* of New Hampshire. For comparative purposes, I give them as they stood at the beginning of 1886 and also 1882.

NUMBER OF ARC LIGHT CENTRAL STATIONS.

	1886.	1888.
In Massachusetts....	26	45
" Rhode Island	5	8
" Connecticut	9	21
" Maine....................	4	14
" Vermont	None	5
Totals................	44	93

Increase of 1888 over 1886, 111 per cent.

CAPACITY OF ABOVE IN ARC LAMPS.

	1886.	1888.
In Massachusetts.......... (Including 2,168 in Boston in 1886 and 2,475 in 1888.)	3,693	7,305
In Rhode Island...........	831	1,961
" In Connecticut	782	3,311
" Maine	520	1,465
" Vermont	None	415
Totals	5,826	14,457

Increase of 1888 over 1886, 148 per cent.

NUMBER OF INCANDESCENT LAMPS FROM CENTRAL STATIONS.

	1886.	1888.
In Massachusetts.......... (Including 9,000 in Boston in 1888).	8 600	74,500
In Rhode Island...........	600	2,200
" Connecticut............	None	11,050
" Maine..................	400	8,100
" Vermont.	None	1,400
Totals.	9,600	97,250

Increase of 1888 over 1886, 913 per cent.

NUMBER OF ARC LAMPS IN ISOLATED PLANTS.

	1886.	1888.
In Massachusetts..........	459	721
" Rhode Island...........	416	731
" Connecticut............	223	332
" Maine..................	10	50
" Vermont	58	128
Totals............	1,166	1,962

Increase, 1888 over 1886, 68 per cent.

NUMBER OF INCANDESCENT LAMPS IN ISOLATED PLANTS.

	1886.	1888.
In Massachusetts..........	16,003	40.619
" Rhode Island...........	4,140	9,546
" Connecticut............	2,117	11,050
" Maine............... ...	1,860	6,908
" Vermont...............	None	475
Total........	24,120	68,598

Increase, 1888 over 1886, 184 per cent.

Total arc lamps, 1886, 6992; 1888, 16,419. Increase, 1888 over 1886, 135 per cent.

Total incandescent lamps, 1886, 33,720; 1888, 165,848. Increase, 1888 over 1886, 392 per cent.

Total arc and incandescent, 1886, 40,712; 1888, 182,267. Increase, 1888 over 1886, 348 per cent.

Those of you who know the ratio of increase in other sec-

tions of the country for the corresponding period, can judge if New England insurance supervision is a detriment to your business, or otherwise.

A whole year without any considerable fire loss in our country from electric lighting, would be a splendid record, but none too good for any of us to contemplate.

While such a result is far outside the bounds of probability, in the present condition of things, it is well inside the bounds of possibility. As well might we hope to revolve the earth from east to west as to hope for anything short of millions of dollars of fire loss annually from the old methods of illuminating by combustion,—the candles, the gas, and the kerosene oil flame, and the accompanying friction match.

INDEPENDENT ENGINES FOR INCANDESCENT STATIONS.

BY WM. LEE CHURCH.

COMMERCIAL success in incandescent lighting depends primarily on the continuous, cheap, uniform, and flexible generation of power.

The service of electric lighting differs from other forms of manufacture in requiring more horse-power per square foot of floor space; in requiring higher speeds; in demanding the power in larger units; in compelling a closer and more uniform regulation; and in calling for more rapid and constant extensions. It will be observed that these peculiarities require individual and special treatment in the generation and distribution of power; and engineering practice as determined in other lines of manufacture may be sadly at fault when applied to electric machines.

It has become an axiom among experienced station managers that "the money is made or lost between the coal shovel and the belt." In other words, other things being equal, the dividend earning capacity of a station is determined by its steam plant, to which the electric apparatus is to that extent in the nature of an accessory.

Incandescent lighting has not until recently made a brilliant record as an investment, and much of the disappointment is directly traceable to the culpable ignorance of the principles of steam engineering which has been displayed. A man who will not venture to cut himself a two dollar vest will not hesitate to exercise his amateur talents on a steam plant, upon the economical and reliable performance of which depends an investment of $1,000,000 and the public service of a city. A long and critical experience in this branch of industry has grounded the conviction that no incandescent station can hope to be financially successful under the ordinary conditions of competition unless based on independent dynamos belted direct from independent engines. Throughout this paper, therefore, we desire to keep constantly in view the opposite systems, namely, a station containing a given number of dynamos of two or three different capacities, each belted direct from high speed engines of corresponding rating; and, on the other hand, the same station with the dynamos driven from one or two slow speed engines, transmitting their power through a line of countershafting and pulleys. Having these pictures well in mind, we inquire:—"What are the essential requirements of a first-class steam plant in an incandescent electric light station?" Taking them up in the order of their importance, we unhesitatingly say;—first, and always foremost,

ABSOLUTE RELIABILITY FOR CONTINUOUS RUNNING.

The electric light company contracts to supply the demands of a diverse and exacting public, and that public expects to find its light on tap every moment in the year. Failure of service in ever so small a degree is palliated by no excuse. Complete reliability is the condition of popular confidence and patronage, without which all other economies and excellences go for nothing.

Again, electric lighting perhaps more than any other industry has its earnings directly affected by the shutting down of its power, since it sustains a direct financial loss for lights out, aside from loss of custom and reputation, not easily regained. Subdivided power reduces this risk to a minimum, and properly directed and applied obviates it altogether. In a station using 2,000 h. p., say, in the shape of two large engines, the loss of income in one night by the shutting down of one of these engines is equal to one-half the cost of an independent engine on the subdivided plan. In other words, as tersely expressed by a manager of experience, a company might better for peace of mind, reputation, and cash balance on the books, throw a 60 h. p. engine into the scrap pile than to shut down the station one hour. The service of electric lighting is similar to the editing of a daily paper in that lost time can never be regained. Most industries can make up lost time by working overtime and by pushing their business in various ways, but in electric lighting

> "The mill will never grind with the water
> that has passed."

Passing from argument to instance, we cite the recent experience of one of the largest stations in the country, operating in the neighborhood of 20,000 lights. This station as originally planned was driven from a pair of Corliss engines, each having a cylinder 28″ in diameter by 48″ stroke, and belting to a countershaft 4¼″ in diameter by about 50′ in length. From this countershaft are driven five dynamos, having an aggregate capacity of 6,000 16 c. p. lamps. Clutch pulleys 8″ in diameter are the means of disconnecting the dynamos when not in service, with similar clutch pulleys for the exciters. The remaining dynamos in the station are each 2,500 lights capacity, and each are driven by a 200 h. p. independent engine, belted direct. Recently in the middle of the heavy run of the evening, an accident occurred necessitating the immediate shutting down of the 6,000 lights, besides doing considerable damage, and involving danger to the employés. It happened that one of the engines with its dynamo was immediately available, and was started within two or three minutes, so as to take up a portion of the load of the large engine. In the same station, at a subsequent time, a key became loose on the valve gear of the engine, necessitating another stop for several minutes. On still a third occasion the crank pin became uncomfortably hot, and was carried through the run only at a great risk and labor. Illustration might be multiplied, but this is used as one among many of the almost evident facts that no electric light station can afford to hang its whole business upon any one source of motive power, particularly when that motive power is distributed through the complex mechanism of countershafting, involving risk of hot bearings, broken pulleys, defective frictions, and what not, any one of which may shut down the whole station. Had these same dynamos been each belted direct from an independent engine the accidents above enumerated could not have occurred in the nature of the case. We do not assume to say but that accidents of some nature are due in any piece of mechanism, but the division of power and generating capacity into comparatively small units, each independent of all the others, affords a practical means of distributing the danger, so that it is essentially nil in its effects. That is to say, had a stoppage of any one independent engine in a similar instance occurred from any cause, the other engines with their dynamos would easily have distributed the load for a short time, without any disturbance or danger whatever, and the service would have been uninterrupted while the repairs were being made or the difficulties remedied.

It has been incidentally remarked in another paper that independent engines afford a safeguard against danger from short-circuits, inasmuch as the current due to the short-circuit will overload an independent engine and slow it down, thus giving warning of the danger. If the dynamo is driven from a single large engine, the motive power will not respond to the short-circuit until it becomes equal to the full capacity of all the connected dynamos, plus the range of power in the engine. Practically, therefore, a single slow speed engine will not feel the short-circuit, but will pull it through until something burns away.

That merit of the steam plant which is most obvious, and which appeals most strongly to the electric light company is, *economy of fuel.*

The advocates of large slow speed engines rely upon the supposed superior fuel economy of this type as the sole offset to its obvious disadvantages. All managers unhesitatingly admit the superiority of transmitting the power directly and without loss from the engines to the dynamos, and more or less readily concede that in its performance the high speed engine will equal the running qualities and durability of the slow speed engine. If with this, say they, we could get the steam efficiency of the Corliss type of engine, no man would hesitate to decide in favor of the convenient, compact, and independent small engine. We take the question at once by the beard, and desire to state that of two incandescent stations operating under ordinary circumstances, and otherwise equal, except only in their power and transmission, that one which has independent direct belted engines will show in its monthly report sheet, not a small amount, but from one-quarter to one-third less coal per lamp hour, than the station driven from a single engine through countershafting, both types of engines being non-condensing. We go yet further, and state that independent non-condensing engines under certain conditions will about equal in economy an equivalent slow speed condensing engine. This is a fact so incontrovertible when actually and candidly investigated, that we do not propose here to demonstrate but merely to illustrate it.

We now submit to the prompt inquiry:—"Will not a high speed engine use more coal per horse-power than a Corliss engine?" Yes. "How much more?" Size for size and load for load not over 10 to 20 per cent. Score 10 per cent. against the high speed engine, and again ask:—"Will not several small engines use more steam than one equivalent large engine even of the same type?" Yes. "How much more?" Load for load possibly another 10 per cent. Score 20 per cent. against the high speed engine, and again ask:—"How an admitted loss of one pound of coal in every five can be reconciled with the statement of a monthly saving of 25 to 30 per cent. in favor of independent engines?" Answer: Simply because we have to deal with conditions as they exist in fact, and not as we assume them to exist.

The reason why independent engines can overcome their moderate lack of initial economy, and pass a large percentage of actual economy to their credit, are mainly two. First,—The use

of a countershaft implies power to run it. Indicator diagrams show that the dead load of such a plant varies from 12 to 20 per cent. of the gross horse-power under full load when in ordinarily good condition, and not infrequently rises to 30 per cent. and over with badly lined shaftings and badly drawing belts. Moreover, it must be borne in mind that the dead load is nearly a constant quantity, and if it amounts to 20 per cent. of the full load, it will under partial load equal and even exceed the net power transmitted to the dynamos. It may easily happen, every night in every station thus powered, that from midnight to morning two to three horse-powers are expended in the cylinder for each effective horse-power recovered at the dynamo pulley. Thus by one stroke and by a single item is the conceded advantage

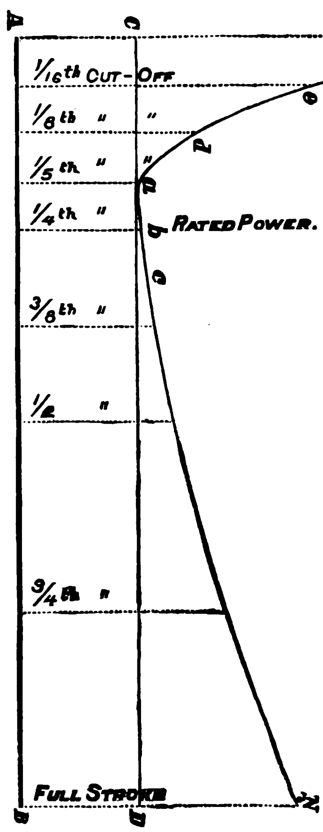

FIG. 1.

of the larger engines, reckoned in coal per horse-power, practically swept away, and large and small engines left standing on an equal footing, prepared to submit to the still more searching question :—"What is the cost from hour to hour of the power actually expended in meeting the fluctuation of the load?"

To consider for a moment some abstract facts in steam engineering, we must note that the steam engine develops its maximum economy (*i. e.*, minimum consumption) only over a limited range of its power. Under normal conditions of pressure, say 80 to 100 pounds in the boiler, this minimum consumption is found only between the points of 1–5 and 1–4 cut off, say from *a* to *b*, figure 1, at which latter point all engines are now rated. At its rated power, therefore, the single large engines of the Corliss type will consume as little as 26 to 28 pounds of water (steam) actually fed to the boilers per indicated horse-power per hour, and if the economy were not affected by the load we could represent the rate of consumption by the straight line CD. If overloaded, however, the rate of water consumption rises as shown on the right hand portion of the diagram, in which the horizontal distances represent the cut-off, and the vertical denominates the actual points of water consumption ; the curve, therefore, being a curve of efficiency at varying loads. It will now be particularly noted that whereas the line rises for an overload, it also rises for an underload, and very much more rapidly. This is well understood to be partly from excessive condensation due to over expansion, and partly from the greater percentage of leakage under short cut-offs. Considering figure 1 to represent the actual performance of a 400 h. p. engine at varying points of cut-off, it will be seen that the engine will be at its best only over a limited range, from *a* to *c*, or, say, from 325 to 450 h. p. An overload is, of course, mechanically injurious, which limits the possibilities in that direction. As the load falls off below 1-5 cut-off the steam rate increases in an enormous ratio, so that at 200 h. p. the engine is using 50 per cent. more than its normal rate :—*i. e.*, at 200 h. p. it is actually using the gross amount of steam which would give 300 h. p. if used in a 300 h. p. engine. At 100 h. p, the waste is fully 100 per cent., and the steam used should develop not 100 h. p., but 200 h. p., if used in a 200 h. p. engine. It must be borne in mind that the diagram is plotted from observation, and is not a diagram of theoretical deductions.

It now remains to determine if the conditions actually obtaining in electric lighting stations are such as will enable a single large engine to develop its normal economy ; and if not, then are they such as will enable the smaller independent engine, with a lesser initial economy, to reach a better gross result under the inevitable conditions as they are found to exist.

The typical daily chart of amperes delivered from an incandescent station of, say, 4,500 lights, is shown in figure 2, of course with variations in different stations, but always of the same general character. The chart is assumed to cover a winter night's run, commencing at 4 P. M., and shutting down at 8 A. M. The heavy irregular line, A B, represents the fluctuation of the actual load, such as would be determined by indicating a series of independent engines, and the area enclosed between it and the base line MN, may be denominated the net power required. The fine irregular line, CD, encloses the gross load when driven by a single large engine, being equivalent to the net load plus the friction of the shafting and pulleys required in transmission. The irregular band lying between AB and CD, therefore, represents the dead load, which is a net loss, due to the friction of shafting.

But, as shown above, this is not the full measure of the loss. We have already seen in figure 1 that an excessive underload requires a *relative* amount of steam which would be adequate to produce a much greater maximum efficiency. Combining the two diagrams, therefore, we would find a third dotted line, EF, which would clearly represent the actual steam consumption required to secure the net work, AB. The irregular band, therefore between AB and EF, represents the total loss expressed in coal. In other words, the entire area, EF, represents the lamps which should be got for the steam expended, whereas, EFMN, represents the lamps actually got for the steam expended. The loss involved is practically 50 per cent. of the total fuel in the whole night's run, which corresponds to observed results in stations

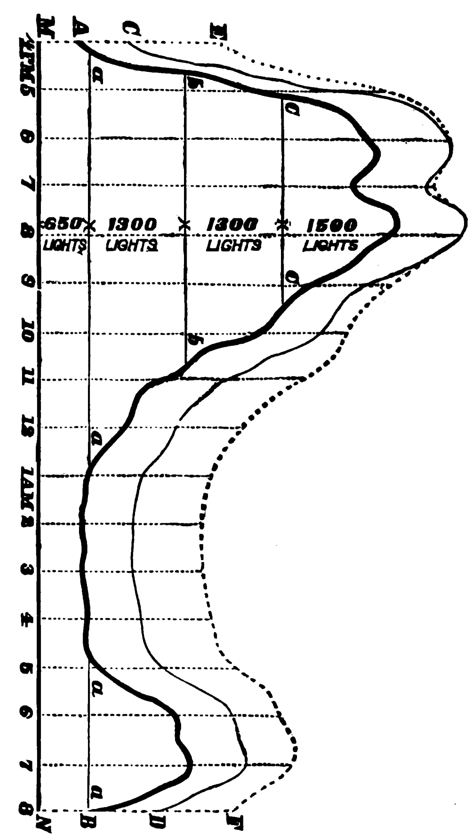

FIG. 2.

whose fluctuations of load are about as indicated. Of course, there are stations in which the net load averages more uniform than that shown, and a better proportionate result would, therefore, be expected from the single large engine with countershafting. We believe it safe to say, however, that there is no incandescent station which will get a load so constant as to secure the economy from a single engine equal to that which can be realized from subdivided power.

We now contrast the performance of independent engines in the same station. The lower narrow band between the lines MN and *aa*, represents the smallest dynamo, or successive loads

of 1,300 lights each. At starting time, therefore, a 60 h. p. engine with its 650 light dynamo is opened, and run continuously until shutting down in the morning. It will be noted that while running, the load on this engine is practically constant and at the point of maximum efficiency. In 10 minutes after starting, the load rapidly increasing, it becomes necessary to start the second 125 h. p. engine with its 1,300 light dynamo, which engine, again, runs on its full and most efficient load, as indicated between the lines *aa*, *bb*. This engine is stopped at 12.45, making another short run in the morning, and is, therefore, running to disadvantage for about an hour. At 4.40 the increase of lights calls for the third engine with its dynamo, which in turn runs until 10.45, and is then stopped. The point to be clearly understood as vital to the whole economic question, is, that each engine while running is loaded to its best efficiency, runs only so long as its load is called for, then stops altogether, and with it all consumption of steam, leakage, radiation, wear and tear, and loss of every nature. Ample time is given to inspect the engine and dynamo if necessary, and the system as a whole develops the last possibilities of commercial efficiency.

The above diagram practically represents the performance of two stations which we once had the privilege of comparing, both of which were of practically the same size and both constructed on the same electrical basis. We were by courtesy put in possession of the monthly reports from both these stations, which showed a ratio between the pounds of coal per ampere hour of 70 to 126 in favor of the station driven by independent engines. A station whose motive power is one or two large engines, therefore finds itself in a position of earning money between starting time and 10 o'clock, and spending it again between 10 o'clock and morning.

We have thus endeavored to make it clear in the above illustrations that the rated economy of the two types of engines is but a small part of the consideration, and cuts practically no figure whatever in actual practice under the condition imposed by the nature of incandescent service.

If any one is now unthinking enough to inquire :—Why not use a number of small Corliss engines in place of high speed engines, if it is admitted that the Corliss type is the more economical of the two?—we would answer, briefly :—First, small Corliss engines are not as economical as small single valve engines, the percentage of leakage due to the four valves and slower speed being much greater. Second, small engines of the Corliss type run necessarily at so slow a speed as to preclude the possibility of direct belting, and to involve full lines of countershafting, with their attendant cost and wast of power ;—Third, the first cost of small slow speed engines is very greatly in excess of that of high speed engines for the same power. We think no one has ever seriously considered, however, the adoption of small independent slow speed engines.

Next in importance to reliability and economy is *uniformity, delicacy and continuity of regulation.*

There is much misapprehension regarding the matter of regulation in engines used for electric lighting. Let us, therefore, ask :—What is good regulation? Good regulation implies, as a matter of course, reasonably small variation in speed, reckoned in R. P. M., between the engine fully loaded and the engine running light. Claims are made that such and such engines regulate to two per cent., one per cent., and even one-half of one per cent., under variations of load. Now, it should be clearly understood once for all, that any decent automatic engine controlled by a shaft governor can be so adjusted as to regulate, not merely to two per cent., or one per cent., but to actually pass the point of exact regulation and run faster under load than when light. So far as regulation in terms of R. P. M. is concerned, one per cent., or two per cent. regulation is sufficiently close for all ordinary purposes.

Second.—The most important consideration in the regulation of engines in incandescent stations is not their variation from minute to minute, but *from stroke to stroke.* An engine may make 300 turns per minute, counting for each successive minute of the hour, and yet may at any given instant be running sensibly above or below this speed, in the effort to meet a momentary fluctuation of load. We say every engine may do this, and we have observed that most engines do do this frequently, the difficulty being, not a matter of the construction of the governor, but purely a question of lubrication. A perfect governor is one which will maintain the speed, not at an *average* of 300 R. P. M., but at the *rate* of 300 R. P. M. for each and every stroke. Any properly constructed governor will retain the average of regulation to which it is set, but it can only secure instantaneous regulation when friction is practically eliminated. It has been our experience that nothing but a complete bathing of the governor in oil will practically accomplish this purpose.

Incandescent lamps require a regulation more delicate, perhaps, than any other industry. Any departure in regulation from stroke to stroke gives a variation of E. M. F., which is speedily destructive to the life of the lamp, that item which, next to fuel economy, is the heaviest tax. The injury is done during the period of acceleration immediately following the change of load, which period is the time between the change of load and the movement of the governor, and this in turn is proportional to the friction. It is obvious that if friction were annihilated the acceleration would be also nil, and the speed, and consequently the E. M. F., would never vary.

Third.—Under the extremely long runs now imposed by electric light service, continuity of good regulation is essential. That is to say, a governor which will regulate when well oiled will fail to regulate when its pins and bearings, being inaccessible under motion, have become dry during a long run.

As to the nicety of regulation obtainable from a slow speed engine, there is no comparison possible. We have already shown that it is not permissible for an electric light engine to vary its speed even from stroke to stroke. All observers know that it is frequently quite possible to count the revolutions of a slow speed engine, particularly when heavily loaded, by the pulsations in the lamps at a distance from the station. A slow speed engine, unless excessive in its fly-wheel capacity, will imperceptibly slacken in passing its centres, and this variation not visible on the engine. becomes a sensible and dangerous variation when multiplied to the speed of the dynamo. The fluctuations of the needle of two voltmeters respectively registering from a high speed and slow speed engine will give abundant evidence on this point.

FLEXIBILITY.

The characteristic of flexibility in electric light stations is one which is frequently overlooked until experience, except in stations where the lowest dynamos is small enough for the minimum unit, demonstrates its desirability. To secure the best possibilities in this direction, it is necessary to use dynamos of two or three different sizes, each being driven direct from its independent engine. The plant being thus divided into independent units of different sizes any variation of demand, either in the total load, or in the load required for different circuits, can be conveniently met. Owing to local causes, the load of a station is not necessarily the same from day to day. It is obvious that a plant in which all the dynamos are hung upon one, or at most two, engines, is essentially rigid in its control of circumstances. whereas a station planned as above indicated, is to the last degree flexible in meeting any variation of load to whatever degree it may occur. All this has a direct bearing both on economy of fuel and incidentals of operation.

We would not wish to imply that the smallest unit in every station should necessarily be the smallest unit as determined by the minimum load existing for any considerable time during the day. This minimum load in the majority of medium sized stations will represent about one-eighth to one-sixth the generating capacity of the station. That is to say, a station of 4,000 lights capacity should have one dynamo at least as small as 650 lights. Beyond this it is, perhaps, advisable that the units be uniform for the sake of interchangeability of parts. The whole question of units of generation must be considered, not in the light of any one rule, but under all the circumstances of each particular case.

MAINTENANCE OF PLANT.

The maintenance account of a plant often defeats dividends. In the use of countershafting an entirely new factor of expense is introduced, pertaining to the shafting, bearings, pulleys, clutch pulleys, belts, etc.

Each bearing of the countershafting will consume oil to the value of at least five dollars per annum, and any considerable amount of shafting involves the pay of an extra oiler to properly care for it. Regarding the two types of engines under discussion, it is undoubtedly true that the maintenance of the high speed engine will be fully as low as of an equal horse-power in slow speeds, as to its direct expense, without taking into account the time lost in repairs. Nearly all the high speed engines are made to gauge with more or less reference to interchangeability of parts. Repairs in consequence are furnished at a minimum of cost, and the parts being light and readily handled, the engine can be stripped, overhauled, and connected up, without the employment of an extra force of men or the necessity for heavy handling. In referring to high speed engines, we, of course, only speak of those which are carefully and understandingly designed for the work put upon them. That is, we wish to draw a sharp distinction between high speed engines and engines speeded high.

The one danger of high speed engines arises from the possibility of charging the cylinder with water which cannot be quickly enough relieved through the valve at the speed at which the piston travels. The fact that no engineer justly entitled to the name should ever allow an accident of this nature to happen, does not in the public mind shift the responsibility from the maker of the engine. Spring relief valves have now been brought to a state of perfection which leaves little to be desired, when the engine is of a type permitting their use.

SPACE OCCUPIED.

This is one of the minor considerations which in certain locations becomes of considerable importance. Not infrequently electric light stations are located near the business portion of the city, where real estate is valuable, and taxes correspondingly

high; and space counts heavily in the capitalized investment. Again, a large building obviously increases the investment, particularly when a building to carry heavy lines of shafting at high speeds must be of unusually massive construction. It needs no illustration to show that independent engines by doing away with the space occupied with countershafting and belts, under the least distance between centres which can be justified, require materially less space per horse-power than any form of non-subdivided power. This is particularly the case where the dynamos are placed on the second floor, over the engine room.

Moreover, the cramped space in which the single engine must develop and distribute its power is against its satisfactory performance. The fact is generally overlooked in drawing comparisons, that a single large engine in an ordinary manufacturing establishment, such as a cotton mill, has in the nature of the case a wide space in which to transmit its power from the slow motions of the engines up to the high speed of the spindles. This means that ample space is given to bring the speed by gradual accelerations, through easy moving shafting of substantial nature, up to a moderately high intermediate speed, and then distribute it to the spindles in small quantities by means of simple, light, fast running devices. In the dynamo room, on the contrary, the space is cramped to the last degree, and the slow running engine must *in short range*, multiply its power to high velocities, and transmit its speed in large units to the dynamos. The whole system of transmission becomes rigid and ineffective, and the loss consequent upon friction, and risk to employés, and the magnitude of disaster when any occurs, are such as in themselves to overbalance all the economy which the most enthusiastic advocates of slow speed engines attribute to them.

EXTENSION OF PLANT.

An electric light station, unlike most other industries, is usually of very rapid and persistent growth, to an extent which is not generally foreseen in the original calculations. The use of independent engines lends itself readily to indefinite extension. The power and dynamos both being divided into like units, each independent of all the others, extension becomes merely a question of more units, without any special preparation in the plan. On the other hand, the slow speed engine with countershafting is necessarily in large units, and to that extent fails to meet the requirements of a gradual increase. The use of the large engine involves an outlay disproportionate to the immediate returns from the first increase as ordinarily provided for, and it necessitates also the operation of the moderately increased plant at a great disadvantage on account of the underload involved, as already explained. The practical operator will readily see the force of this important advantage on the side of the independent engine.

FIRST COST OF PLANT.

This consideration, although really of the least importance among those enumerated, is distinctly on the side of subdivided power. The price of high speed engines per horse-power is now fully as low, and generally lower, than that of slow speed engines. Cost of foundations is materially less, as is also cost of erection and handling for repairs. There then comes into the question the clear saving of all the money invested in countershafting, pulley blocks, heavy belting, clutch pulleys, receiving pulleys, and similar devices. In the station to which we referred above the extra transmitting devices necessitated the investment of a sum not less than $6,500.

The price thus expended for worse than useless machinery would be sufficient to purchase practically 500 h. p. of independent engines, adequate to generate 6,000 lamps, showing a net earning capacity of at least $18,000 per annum.

When we contrast this with the net losses due to the system of concentrated power, as above discussed, it leaves no room for argument as to the advantage of independent engines in electric light work.

HOW CAN WE PROTECT OUR WATCHES AGAINST THE INFLUENCE OF MAGNETISM?

BY DR. P. LANGE.

I HAVE been invited to deliver to this convention an address on the influence of electric currents upon small magnetic matter. I can comply with this request in no better way, perhaps, than to devote myself especially to the discussion of this most subtle influence as applied in particular to the delicate mechanism of our watches. Every man among us has doubtless been often impressed with the idea that absolute accuracy is the most desirable quality a time-piece can possess; that reliability is most essential to render efficient a guide so frequently consulted as the watch. You will therefore acknowledge the real importance of the question as to how we can best protect our time-pieces from the influences of a magnetism that must render them inaccurate and unreliable. Since the introduction of powerful dynamos has taken place in large electrical establishments, and in the many buildings supplied with independent and separate lighting plants, it has become evident that the watches carried by persons coming in proximity to the dynamos (whether such persons be constantly employed near the dynamos, or only visitors to the works, it matters not) are very likely to become magnetized. Once under the influence of magnetism, the time-pieces must very soon show the effects of it, by either losing or gaining time, or stopping altogether; and the cause thereof is such, from its very nature, as would be liable to puzzle an expert watchmaker to remove. The advent of electricity in its modern and manifold branches of utility has forced upon us the importance of this question: How can we prevent this magnetism from gaining a damaging influence upon our watches? or, if not prevented, how can we best and most speedily repair the damage done?

Let us not look upon the question lightly, but rather in all earnestness. Let us bear in mind that, while the powerful dynamo in the engine room, in the manufactory, the business house or the ocean steamship sends forth its currents through many lines to furnish light or power, it sends forth also a very different influence, and one that makes mischief with the watch carried by the engineer or electrician, the visitor to the works, or the captain, or the pilot who may happen to approach for a moment within the influence of such a dynamo. Let us not forget that, in the latter event, serious results may follow, for, by the captain's chronometer, in conjunction with the compass, the great ship is sailed. We should bear in mind that, in the manufacture of our best watches, the object of the maker is to confine in the smallest space possible the greatest strength and durability. In order to accomplish this object, he finds it necessary to use, for the principal parts of the watch, hardened steel, a material decidedly susceptible to the influences of magnetism. The hair spring and the balance wheel—vital parts of the watch—are thus frequently constructed; and even though the balance be made of a combination of metals, the steel in the little points on the wheel may be attracted to the little steel screws necessary to perfect firmness in the larger mechanism of the watch, for these screws may be readily charged with magnetism of sufficient force to be long retained and to exert a continual influence over the other magnetic matter. This escapement wheel, likewise of steel if durability be desired, becomes easily magnetized also, and its movement is seriously retarded. Then the hair-spring, with its delicate coils close together, may be so polarized that the coils on the side next to the nearest steel screw will all adhere to each other and play havoc with the motion of the watch.

Thus our very best time-pieces are most susceptible to the influence, which may, and often does, retard them to the extent of several hours a day.

In my work as an investigator of this subject, which has extended over a period of several months, I have formed three separate solutions of the problem: First, to have the watch made of material that cannot be magnetized; second, to inclose the works in an iron case, so as to shield the vital parts of the watch, and third, to apply efficient means to demagnetize the watch that has not been favored with the safeguards.

With regard to the first solution, I have had occasion to experimentally test its efficiency. I have applied the most complete magnetic tests to watches made by a well-known watch company, which were claimed to be perfectly free from all magnetic influences. The hair-spring and balance wheel of these watches are made of palladium. I have no hesitation in saying, after subjecting these watches to the strongest magnetic influences in the Westinghouse Electric Works, that their claim to recognition as non-magnetic time-pieces is fully sustained. I have had one of these watches perfectly timed to run with another, and subjected the two to opposite extremes as regards magnetism, yet discovered no deviation in their time keeping. The one was wholly free from the magnet influence; the other was running at a point between the pole-pieces of a most powerful magnet. I have watched both of them closely for weeks, without being able to detect any difference in their time.

Taking the hair-spring and balance wheel from a watch, I have placed them upon a little cork float in the water, and then approached them with a most powerful magnet, without being able to detect the slightest motion of the little float or its burden; whereas the ordinary steel hair-spring and balance wheel, subjected to a similar test, were so strongly attached that they not only moved the cork float but jumped from it to the magnet instantly.

While it is true that the screws and a large portion of the other mechanism in these watches is made of steel, yet all the delicate movements in the work are so entirely non-magnetic that, although the steel parts should be charged with magnetism to the highest degree, there would be no perceptible effect exerted upon the running of the watch.

Concerning the second solution of the problem, that is, shielding a steel watch against magnetic influences by inclosing it in an iron case, I would say that I have not personally experimented with them: but acquaintances of mine, entirely competent to do so, have given me an excellent idea as to what such watches are capable of. Watches, in such cases, have been very successful in resisting the ordinary influences of the dynamo rooms. But I would not advise that they be exposed to the influence of very

strong fields, because, in that case, they would be magnetized and lose time.

Now, for the third solution of the problem. Since it is true that comparatively few non-magnetic watches are in use, and that there are a great many of the ordinary watches with steel works, the question comes up, naturally: How can we best demagnetize the watches if they have become injuriously magnetized?

An old way of doing this was in placing the magnetized timepiece in close proximity to a dynamo, then revolving the watch rapidly by means of some mechanism and slowly removing it from the magnetic influence. This is a very unreliable cure at best, and, in many instances, quite ineffective. A much better method has presented itself to me. I had occasion, recently while constructing instruments for the alternating current, to observe some facts in connection with this kind of current and its peculiarities, which were suggested to me as being entirely available for use in the process of demagnetizing watches. In sending an alternating current through a solenoid, without breaking the circuit in the latter, I found that the steel core had lost its magnetism entirely. Magnetizing the core as strongly as I might before this operation, it would be, as I discovered, entirely demagnetized after submission to the process described. Then I found the same proposition to be equally true as applied to a whole handful of steel particles. They might adhere to each other ever so strongly before the operation; but if I endeavored to pick one of them out of the solenoid with the circuit undisturbed, the steel particle would come out entirely alone, wholly demagnetized and free from attraction to the others. Then I tried a watch whose steel pieces were thoroughly charged with magnetism, and I found that the same process exerted the same effect upon the watch as upon the steel core or upon the many particles of adhering steel. It was utterly demagnetized in all its parts—perfectly cured of its magnetic ailment. It would be unsafe to bring such a perfectly restored watch within the influence of magnetism, unless the owner should be desirous of again resorting to the still reliable process described. The solenoid need not be described to electricians. It is a very simple contrivance filled almost to the top with soft iron wire, leaving just room enough at the top, if designed for the purpose described, to allow the insertion and removal of the watch in the manner noted. Any person can apply the test successfully, and, if it be in a jeweler's store or any other place lighted by incandescent lamps supplied for alternating current, the person need only remove the lamp from its socket, insert an attachment plug in its stead, connecting the current with such a solenoid, dip the watch in the hollow end of the solenoid, and, after leaving it in there awhile, remove it without disturbing the circuit. In this way a perfect cure for magnetized watches might be applied in any store, factory, or other establishment having alternating incandescent lighting plant. In conclusion, I have only to say that the first solution of the problem described above, namely, that of getting perfectly non-magnetic watches, is the best and safest one for those whose time-pieces are liable to be subjected to magnetic influences. I may also add that the third method or cure described demonstrates the wonderful resources of the alternating system of electricity, which, though it may work damage like other systems, has yet within its own qualities a perfect curative power, which cannot be claimed for the continuous or direct current.

THE ENERGY OF ALTERNATING CURRENTS.

BY O. B. SHALLENBERGER.

The adoption of the alternating current for electric lighting has introduced a number of questions in regard to its measurement which have an important practical bearing, since they involve the subject of the relative efficiency of the direct and alternating systems; and for this reason, perhaps, a few words on this subject may not be amiss.

It is not proposed to enter into a mathematical discussion, but rather to offer a few illustrations and examples which will assist in a general understanding on the subject, and at the same time prove the uncertainty of the well-known rules for direct currents, when generally applied to alternating currents. Under certain well defined conditions such methods may be employed without sensible error, and fortunately for the electric lighting industry, these conditions are naturally present in the exact kind of apparatus necessary for the simple and economical distribution of the alternating current.

In estimating the amount of energy expended in a circuit traversed by a direct or continuous current we are accustomed to base the calculation on measurements of the difference of potential between the two points of the circuit in question, and at the same time, the current traversing that circuit. The product of these two quantities, as is well-known, gives a correct measure of the energy of the circuit expressed in watts. This method may or may not be applicable to alternating currents, the distinction depending upon the presence or absence of self-induction in the circuit. In the case of a straight copper wire going out from the source of current and turned back on itself in close proximity, it may be assumed that self-induction is practically absent, and hence no sensible error would be involved in taking the product of the difference of potential between any two points, as measured on a Cardew voltmeter, and the current traversing that portion of the circuit as determined by a Siemens dynamometer, and then using these two factors in the product which represents the amount of the work done. This would give a correct result; but the introduction of a coil of wire wound in one direction, especially when it surrounds an iron core greatly modifies the conditions, and causes an error the amount of which is dependent on the form and size of the coil. The reason for this is that an additional element of self-induction has been introduced, with consequent retardation of the phases of current. This simply means that, as the difference of potential alternately rises and falls and reverses its polarity, the corresponding fluctuations of current do not occur at corresponding instance of time. The want of synchronism may be of any amount between zero and a quarter of a complete wave length. When there is no self-induction present in the circuit, there is no displacement, but a departure from this relative position may be produced by introducing self-induction into the circuit, and to a point which may theoretically cause the waves of the current to lag a quarter of one complete alternation behind the waves of the electromotive force, although it is impossible to realize this amount in practice.

Let us inquire now what is the effect of this displacement on the amount of energy expended in the circuit; but as a preliminary step it will be well to examine the case of a secondary battery which is being charged from a suitable direct current generator. Suppose first, that current is supplied from the generator with a sufficient electromotive force to overcome the counter electromotive force of the cells and produce a certain flow of current. We may introduce into the circuit a suitable ammeter to determine its amount, and connect across the circuit a voltmeter, and by the product of the indications of these two instruments we obtain a result which shows the expenditure of energy at that time. But if, later in the process of charging, the speed of the generator is reduced to such a point that the counter electromotive force of the battery is sufficient to overcome the electromotive force of the generator and cause a flow of current in the opposite direction, it is well understood that the battery would no longer be charging, but would be running the dynamo as a motor, and consequently expending energy upon it. If the resistances of the armature and battery are low, the readings of the voltmeter and the ammeter might be exactly the same as in the former case, and the product of these two factors would of course show the same amount of work done. In the absence of any other information than the readings of these instruments it would be impossible to judge whether work was being done by the generator on the battery or by the battery on the generator. Another element requires consideration, and that is the direction of the current as related to the difference of potential across the circuit. Referring to diagram 1, a generator is shown at G, supplying current to charge a battery at L. Let it be assumed that the electromotive force of the generator is in such a direction as to make the upper conductor positive, with relation to the lower. Calling this a positive electromotive force, a current in the direction of the full arrow would be positive, and one in the direction of the dotted arrow would be negative. Whenever the generator is doing work on the battery the current flows from the positive to the negative conductor through the battery, or in the direction in which the generator tends to deliver the current. If we had called the electromotive force of the generator negative, this would be a negative current. We can assume either, but in each case the current and electromotive force have the same sign. When, however, the electromotive force of the generator falls sufficiently to allow that of the battery to overcome it and send a current in the opposite direction, as shown by the dotted arrow, the conditions are reversed; that is, the battery is doing work on the generator and driving it as a motor, but without the polarity of the external circuit being changed. We now have a positive electromotive force, a negative current in the battery, and work done by the battery on the rest of the circuit.

The foregoing is only an illustration of the general law that when the difference of potential between two points on an electrical circuit is of the same sign as the current traversing it, work is being expended on that portion of the circuit; and conversely, if they are of opposite signs, work is being restored by that part of the circuit. It is therefore necessary to know the relative polarities of the current and electromotive force as well as their amounts, in order to have a complete knowledge of the energy of a circuit. The same thing is true of an alternating current, that is, we must know whether the instantaneous values of electromotive force and current have the same sign, as well as the values themselves; and this can only be the case where no self-induction is present, or in the practically equivalent case in which the self-induction is so nearly neutralized as to be of no relative importance.

Referring now to diagram 2, there are shown two curves in the upper figure, E and C. E represents the phase of electromotive force of an alternating generator, and C, the corresponding current through a circuit possessing a certain amount of self-induction. Distances along the horizontal line are taken, as usual, to

represent successive periods of time, and the relative amounts of current or electromotive force are represented by the vertical distance above or below this line, those above being called positive, and those below negative. It will be seen on inspection of the figure, that at the instant (shown at 1) the electromotive force is zero, while at the same time the current has a considerable negative value. Again at the point 2, the current falls to zero, while the electromotive force has risen to the amount shown by the vertical line at 2. At 3, we have an instant at which the current and electromotive force are of opposite sign. Here we have three distinct cases, in the first two of which no work is being done, and

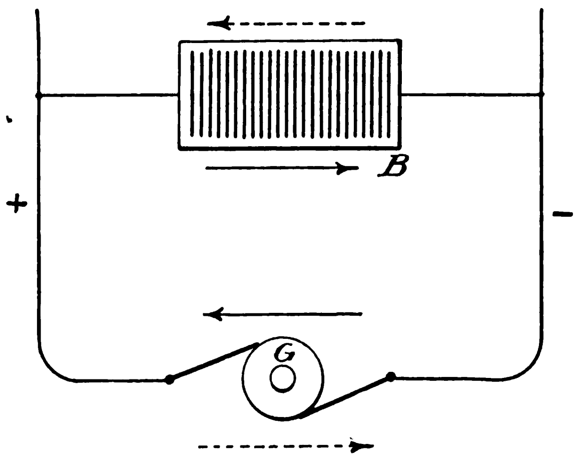

FIG. 1.

in the third, work is being done by the circuit on the generator ; but in each case an effect would be produced on the instruments used for the measurements of electromotive force and current. In fact, taking independent continuous measurements of the electromotive force and current, it is quite evident that the same results would be obtained without regard to the time relation of the phases, so long as the form of each remained unchanged ; and for this reason the result would be the same from such measurements whether the curves were coincident in time, and the current curve occupied the same space as the curve E, or were displaced as shown in the diagram. In the former case, as there is no displacement of phase, the products of the current and electromotive force at each instant would be positive ; that is, work would be done at each instant upon the external circuit except when passing through the values of zero.

The effect of the displacement of the current phase is shown in

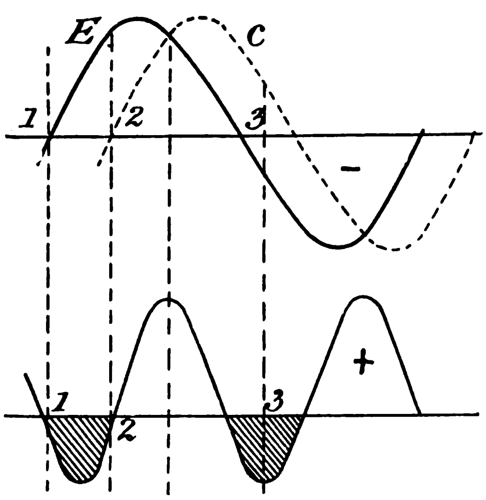

FIG. 2.

the lower figure, where a curve is drawn to show the phase of work done at each instant of time when the lag of the current phase is of the amount here represented. At 1, no work is being done, since the product of E and C contains a zero factor. Between 1 and 2 we have work done by the coil, since the electromotive force is positive at the same time that the current is negative. Then we have a period in which work is expended by the generator : and then at 3 again, work is restored by the circuit to the generator. By still further displacing the current phase the amount of work restored to the generator may be greatly increased. The example I have taken, a retardation of about one-sixth of the phase length, is a very moderate one, and easily realized in practice, and yet the amount of energy restored to the circuit in the work done by the coil is nearly one-fourth of the apparent amount of energy expended, as shown by the product of current electromotive force. The diagrams are not intended to show the exact forms of current phase, or of the phase work done, but they are sufficiently near average conditions for the purpose of illustration.

A retardation of one-fifth of the phase restores about one-third of apparent energy to the circuit, and beyond this point, the proportion restored increases in a high ratio.

The actual work done can never be more than the product of current and electromotive force, and may easily be only a small fraction of that amount.

To show that this retardation is not an imaginary thing, but may have a very decided influence on actual measurements, I will describe two experiments which show phenomena that can be accounted for in no other way, or at least, cannot be explained by the ordinary rules of direct current measurement. An experiment by the writer similar to the second of these was described by Mr. Stanley, in a paper before the American Institute of Electrical Engineers some weeks ago, and is still another example of the same phenomena.

In figure 3, two conductors A and B, are shown, between which an alternating difference of potential of 100 volts is maintained, and indicated on the Cardew voltmeter V. Between these two conductors a third, C, is placed, and two Cardew voltmeters, V 1

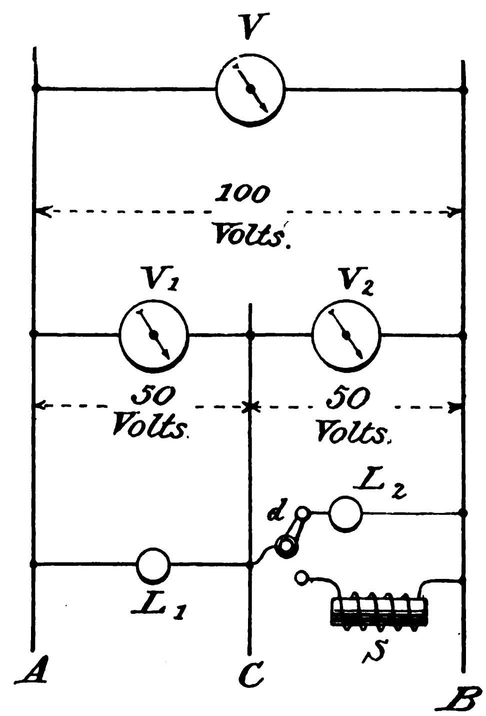

FIG. 3.

and V 2, are connected across the two circuits, and show by the sum of their readings the difference of potential between A and B. They should, under ordinary conditions, agree with the reading of the one at V. Between A and C is connected an incandescent lamp, L, and between C and B, through a switch, *d*, the circuit may be closed either through the lamp L 2, or through a coil of wire S, which surrounds a soft iron core. With the connections as shown in the diagram ; that is, with the switch connected to the lamp, L 2, a perfect balance is obtained, and by adjusting the difference of potential between A and B to 100 volts, we obtain readings of 50 volts on each of the voltmeters, V 1 and V 2. If, however, the switch *d*, be transferred to the point which connects it with the coil S, a somewhat remarkable effect is observed. The readings of the voltmeters at V and V 1, remain constant, since the coil has been so proportioned by trial as to exactly replace the lamp, L 2, and maintain L 1 at exactly the same degree of luminosity ; but the voltmeter, V 2, instead of remaining constant in its indication, as might have been supposed, increases its indication to 80 volts, so that we have our choice, so to speak, of two measures of the difference of potential between the conductors A and B. These are of such large cross-section as to be of sensibly the same difference of potential throughout their length. Measuring at V, we have 100 volts as before, but at V 1 and V 2, we have the sum of 50 and 80, or 130 volts. It is quite evident that there is some condition present, entirely remote from any which could be produced by the action of a direct current ; for it is absurd to suppose that at the same instant of time we can have two separate values

for the difference of potential between the same two points. The natural inference seems that these measurements show in reality only the average of effects which occur successively, although they appear to be simultaneous.

When an impulse from the generator occurs, current flows through V 1, and V 2, instantaneously, and this would give a reading of 50 volts on each if acting alone ; but the same impulse, acting through the coil S, produces a current which, owing to the self-induction of the coil, lags behind the electromotive force, and therefore the coil must restore work to the circuit at some point in the phase. This work is partly expended in the voltmeter connected to the coil, and for this reason it gives a higher reading than the other.

Figure 4 shows a second arrangement in which the current is indicated by a Siemens dynamometer, D, and the difference of potential is maintained constant by the electrometer E. The current may be adjusted to the proper amount by means of the resistance R, introduced in the circuit. An incandescent lamp, L′, is also placed in the circuit in series with the dynamometer, to indicate to the eye any fluctuations in the current. At L, a similar lamp is placed, and around its terminals is shunted a properly proportioned coil, S, surrounding an iron core. A Cardew voltmeter, V, is connected at the same points to show the difference of potential. With the switch closed the normal current passes through the lamp, L, and a difference of potential of 50 volts is shown on the voltmeter, V. The dynamometer shows one and six-tenth amperes to be passing through the circuit, and the electrometer indicates 1,000 volts. On opening the switch a slight increase of current is shown by the dynamometer D, while the difference of potential at E, is constant. The only change in the arrangement of the circuit is that the current instead of passing through the lamp, L, and the

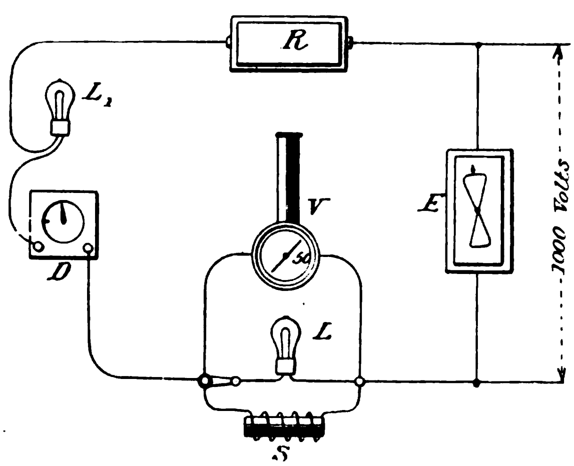

FIG. 4.

coil in parallel, now passes through the coil alone, and yet instead of 50 volts, the voltmeter now indicates 148 volts ; so that we apparently have 98 volts more in the circuit without noticeably changing the difference of the potential at the terminals, and without sensibly changing the current ; or, to look at it in another way, we have, under a constant potential at the extremities of the circuit, introduced an apparent resistance, and at the same time increased the current traversing the circuit. We have here a case similar to the former one, and as the explanation is much the same, it need not be repeated.

The question naturally arises, what influence does this new element of self-induction have upon the possibilities of practical measurements of the alternating current in commercial work? As was stated in the beginning, the practical effect is almost negligible, for there are two cases in which the time element enters to such a limited extent, if at all, that the measurements may be made with perfect success in precisely the same way as if direct currents were employed.

These are, first, the measurement of current through an incandescent lamp supplied by an alternating current directly from the generator ; and second, the current supplied to lamps through the medium of converters with cores far below saturation and carrying a fair proportion of their full normal load. There is a third case, however, which arises in practical work, in which the central station instruments give a somewhat false notion of the actual energy being transferred to the circuits, and this is the one in which a large number of converters are connected to the primary circuit, but with the secondaries open. In this case the effect of self-induction is at its maximum, and there is consequently a lag in the circuit, which in a well-constructed converter approaches the theoretical limit of a quarter phase ; at which point no energy would be consumed, while at the same time a considerable reading might be shown on the current instruments. This apparent difficulty is not a real one, since even the full amount of current shown by the ammeter only constitutes a small percentage of the total output of the plant, and may practically be neglected. Even a small number of lamps in service distributd among the converters greatly reduces this error, and for this reason, even while running with a light load, the ammeter at the central station very nearly corresponds to the number of lights in the service ; while at full load the reading is as accurate as if the current passed directly from the generator to the lamps.

It ought to be evident, however, from what has been shown, that the method which has been sometimes adopted of turning off all the lamps from the secondary circuit, leaving the primary connected to the generator, to show the amount of energy lost in conversion, is apt to give very misleading results unless the proper correction for retardation is applied.

The best proof of economy in the use of converters is, that a test of the power expended in running a dynamo at its normal electromotive force, with its circuit closed through the primary coils of its full complement of converters, is the same as when the primary circuit is entirely open, within the ordinary limits of error of measurement.

THE DISTRIBUTION OF ELECTRICITY BY ALTERNATE CURRENTS.

BY T. CARPENTER SMITH.

THE distribution of electricity by means of alternating currents, though comparatively new in this country, has already reached such an enormous importance that it is with great hesitation that I venture to speak upon it, even though limiting myself to the strictly practical side of the work dealing with the apparatus as we received it from the hands of the manufacturer, and leaving out entirely the question of the efficiency of dynamos and converters. It is only that the knowledge that the mistakes of those who centre upon any new line of business are the rounds of the ladder by which we all attain success, that enables me to lay before you some of the conclusions at which I have arrived after several years experience of varied types of electric lighting, both by the arc, by the direct current incandescent, and the alternate current incandescent.

The subject naturally divides itself into several heads, but I would first say that it appears impossible to lay down any general plan of distribution which would be practicable in all cases. In almost every town a different plan will be required, and this will depend in most cases purely upon local circumstances. Systems that would be admirable for thickly settled and densely populated districts will not be successful in thinly populated and widely scattered ones. I wish it to be understood that whenever I speak in this paper of success and successful systems, I mean successful entirely in a commercial way, and the conditions of this commercial success will vary in every town and district. I will therefore content myself with describing the method which I have found to be most successful in the various districts with which I have had actual experience, and leave it for those who may be called on to design and lay out the lighting of any particular district to judge for themselves which line of action to pursue.

Naturally the first part of my subject is the dynamo, and the station detail. I have tried the small and large dynamo, and have concluded that it is a very great point to properly proportion the right unit of dynamo to the probable size of the station ; that is, not to have dynamos of different sizes, but first to determine what the unit shall be, making it as large as possible, and then make your whole apparatus additions to that unit size. This simplifies matters very much, enabling machines to be interchangeable, both as regards their parts and their work, and this I am sure will be admitted by all who have ever had the annoyance of a break-down on engine or machinery when perhaps they had standing idle plenty of apparatus, which, from various circumstances, could neither be used itself, nor be robbed to repair the break-down.

I would drive each dynamo by a separate engine, and this for several reasons : by proportioning the engine to the dynamo, it will be possible to have the engine running slightly overloaded when the dynamo is doing its utmost during the hours of heavy lighting, and as this extreme load falls off to the lighter hours of running, the engine will be working at its point of best economy, instead of running underloaded, and thereby wasting steam. Thus we use in our station on Virgin alley dynamos of 2,500 light capacity each, driven by 200 h. p. engines. During 16 hours of the day these dynamos run driving 2,000 lights, and the engines are cutting off at quarter stroke and developing 200 h. p. During the other 8 hours we have driven these dynamos as high as 2,800 lights, during which time the engine was of course overloaded, and not working to so good an economy, but eight hours of overload is not nearly so wasteful as 16 hours of underload ; again we have had it very forcibly demonstrated more than once that if the engine be only large enough to drive the dynamo with ease, a heavy short circuit on the mains outside will simply pull the engine up or slow it down, without destroying the dynamo, and only those who have seen a 9-foot fly-wheel running 250 revolutions per minute on a 200 h. p.

engine, slowed down in almost an instant of time, can realize the terrific strain to which everything is subjected in such cases, and I would mention right here that the element of time is a very great factor in such circumstances, as in an accident of this kind mischief is often done before the safety catches can melt out. The direct belting of the engine to the dynamo is always to be preferred; shafting is, except under exceptional circumstances, simply a nuisance for incandescent electric light stations, and the economy of one large engine over many small ones has been enormously overrated. For arc light work, where the lights are all lit and extinguished at certain hours, the large engine is good, but for incandescent work, where the load is absolutely out of the control of the station, it is impossible to steadily run a large engine at anything like its most economical load, whereas, with separate engines the machines can be started and stopped the moment that they are needed or are done with, while the oil from shafting will always cause more or less grease and dirt.

For central station use, except for very small plants, I should certainly use separately excited dynamos, and should do the exciting from two or more dynamos each capable of exciting the whole system. In this way, with the station running at its normal, the only regulation required is that obtained by working the simple rheostat in the field of the motor, and as we have designed our station at Pittsburgh, this will mean the regulation of 15,000 lights by one 6 inch hand-wheel.

Of course each dynamo should have its separate field rheostat to make up for any slight difference in speed of engines. The two exciters should be so arranged that they can be run together or separate, or that either can do the whole work, which, of course, is easily accomplished by feeding them into a separate pair of exciter bars on the switch-board, and charging the fields of alternating dynamos from these. The general question as to whether it is better to use separate circuits for separate machines, or to couple them into a general set of 'bus wires, and distribute from them, is too large to be lightly decided, as also is the question as to whether it is best to run separate circuits for separate districts or to run into a general system of high pressure mains outside of the station, feeding into these mains at different points, and again distributing from them, and I am not prepared to express any preference, but think that local circumstances will generally decide this question. There seems to me little doubt that in underground systems the net work of high pressure mains would be the best, but for overhead work we have adopted the system of separate circuits from separate dynamos, using a switch-board which enables us practically to run any circuit or any number of circuits from any dynamos, and running these dynamos separately and not in multiple arc. In spite of the utmost precautions, the unregenerate telephone and telegraph men are always hauling wires across our high pressure mains and feeders, and while their wires and not ours generally suffer, after hearing the frightful roar that comes from the dynamo which is running the particular circuit so crossed, we always feel relieved to know that only one dynamo is in danger of being thrown out by the slipping off of the belt, and a 20-inch belt is not a pleasant thing to have flying around loose. In case of any trouble, such as fire, circuit broken down, or anything of that sort, we can pull the switch of that particular circuit, until we can cut out the part affected. The system that I have laid out for use here will, of course, take a long time to introduce, in view of the fact that we are changing from one system to the other, and have to be governed largely by the location of our lighting, our existing lines, and the possibility of putting up additional pole lines, but it takes in my vision the form of a series of heavy mains down the main streets with cross lines on the cross streets, with switches on the poles enabling any of the cross streets to be run from the mains on either of the main streets, so that in case of a fire on one of the main streets the section represented by the block in which the fire occurs, can, by the pulling of two switches be completely cut off, while the cross streets on either side of the section will enable the lights beyond the fire or broken circuit to be operated, with only the trouble of a slightly larger percentage of loss and the consequent dimming of the lights.

For the main overhead wires, I must harp upon the old string which cannot be struck too often, namely, high insulation. For 100 volt current work, the old standby of "undertakers'" wire will pass; but when it comes to 1000 volts difference of potential, and 130 or 140 amperes to back it up, one realizes very quickly that nothing is too good to curb this fiery steed. We are still paying the penalty of early ignorance in having many circuits of underwriters' wire stretched upon our poles, and I have stood and listened with fear and trembling to the howls of a new dynamo which had only been in operation for a few hours, when we had four short circuits in as many minutes, caused by dead wires falling across these mains on a wet day; while on the other hand I have been gratified beyond expression to see our linemen remove 10 or 12 old bare iron "District-call" wires which had been hanging all night right across our high pressure high insulation mains, and this during a soaking rain. Especially should the service wires to the converters be of the best insulation, not only for fire, but for protection to life, for while the shock does not kill, even a 100 volt shock may make a man start so as to fall off a ladder; and any death or injury will be credited to the electric current. We have adopted a standard of a separation of three feet between the two wires nearest each other on the cross-arms, and do not allow, under any circumstances, the tapping of service lines directly to these wires. All services must be attached through the medium of a small spreader on the end of the cross-arm, which I have no doubt all those present have noticed on the streets.

In some districts where the number of lights in each building is small, we run secondary low pressure mains, and place the converters on the poles, and make our distribution from our secondary mains, but our experience has been that this is not a very satisfactory way of doing. The percentage of loss on those secondary mains, unless the wires are very large or the converters very numerous, either of which is objectionable, causes such a decided variation in the lights as to give ground for numerous complaints.

The question of the loss on the high pressure feeders and mains is one which I think has not received enough attention. When the alternating system was first introduced, so much was said about the extreme smallness of the wire required that a great many of the arc light fiends throughout the country who had been accustomed to congratulate themselves on the fact that No. 6 wires was big enough for a 20-mile circuit, immediately jumped to the conclusion that because it was a high tension current, No. 6 wires was big enough for all cases, and consequently more than one case of dreadful grief has arisen. I have laid out our circuits on a certain fixed plan, which is, that each circuit shall be laid out for 1,300 lights (that being the size of unit which we at first adopted) and made of such sizes as to carry these 1,300 lights with a loss of not more than two per cent. with the whole load on. By having feeders large enough for this, we prevent any noticeable differences in candle power from one end of the circuit to the other, and should we be even compelled to run a light circuit and a loaded one on the same machine, the increase in the one or the decrease in the other would not be injurious. Of course, we try to so arrange our circuits that the load shall vary about the same on each, but the suddenness with which storms creep up in Pittsburgh makes our load very uncertain and erratic. We have run for three days and nights with only a little more than half of the machinery in operation, and then from Monday night to Friday morning have had to run every incandescent machine in the station under a load that fairly staggered it.

I now come to the question of the placing of the converters, and for this I think that you may safely lay down the general rule that wherever you are simply carrying current, do it at high pressure, and keep your low pressure for the purely local distribution. With proper precaution, I do not see that there is any real danger in carrying the high pressure wires into and through the building. If a 1,000 volt current from a central station is not to be allowed in a building on account of its dangers, then every arc light plant, whether from central station or an isolated plant in the building, must be condemned for the same reason. Of course, the cases where two wires of an arc circuit with a difference of a potential of 1,000 volts are run close together, are not nearly so many as must be the case where there is constant difference of potential of 1,000 volts in the alternating system, and again, of course, we have the fact that the direct current on arc circuits is generally not more than 20 amperes, while, as I have remarked before, our alternating circuits run as high as 130 amperes; but the fact that one is a direct, and the other an alternating current largely makes up for this difference. With all due respect for the many gentlemen who have discussed so learnedly of the deadly alternating current, and on the frightful results therefrom, and whose experience with the alternating system is mostly confined to the magneto bell or induction coil, I must maintain that the alternating current, while it is in mild doses of from 100 to 200 or 300 volts intensely more disagreeable than the direct current of the same voltage; when it comes to 1,000 volts or more it is very much less dangerous to life. I make this statement with the more confidence that I have tried them both, and we have in our station here not one but half-a-dozen cases where our linemen and dynamo men have received the full 1,000 volts, generally being pretty badly burned at the point of contact, but experiencing no ill after-effects, while whenever any of our men receive a shock from one of our arc machines they are nearly always sick for a day after. This very fact of the alternating current being more disagreeable adds to its safety, as the men are disinclined to work on the wires, even when there is only a slight leak, where with the direct current they will often take much greater risks. In carrying our high pressure wires through the buildings, we have adopted the invariable rule that they must be carried on porcelain insulators, and the wires themselves waterproof in all cases. We do not allow them to be run in moulding, but where the wires are to be concealed or protected a casing is run around the wires, outside of the porcelain insulators, and hard rubber must always be used for floors and walls. The converters are all placed with porcelain knobs behind them, giving an air space of two inches between them and the wall, and we prefer in all cases to put them against brick, rather than

against wood or plaster. I understand that in some districts the use of converters inside buildings has been forbidden, but I think that this position is a most unjust and untenable one. The only argument that can be brought against their being placed inside is the danger to life or of fire. For the first the converter is well insulated, and is placed high up out of reach, and most potent argument, though one, I am sorry to say, often refused recognition, is, it is not placed there to be handled. As regards the danger from fire, all the converters with which I have had any experience are boxed up completely in iron cases, the only opening in which is a small one at the bottom for ventilation. They cannot possibly get hotter than the melting point of lead for the simple reason that if they should the fuses would blow out and cut them out of the circuit, and any one who has performed the old experiment of melting lead in a piece of paper can easily see that this heat is not liable to set anything on fire, and even should the converter burn out no flame can escape from it to set fire to anything, however inflammable. If the converter is to be banished from buildings on account of danger from fire, then every stove, high pressure steam pipe, and for that matter every gas jet must also be banished.

In a Chinese fire cracker lately published, I find the statement that inspector McDevitt has relegated to the celler all converters, and that he says that in the first case of explosion or fire from them, they will have to go to the street. Now, as vice-president of the company owning these converters, I have simply to say that this is not so, and that the converters are placed all through the buildings, wherever we may desire to have them, and only three or four are in cellars. Moreover, so far from Mr. McDevitt making any such statement, he has steadily refused, even under the most urgent solicitation of the Chinese gentlemen, to make any such restriction, but has very properly stated that until an explosion or fire occurred, he can take no such action. I speak of the publication as a "fire cracker" for three reasons,—first, because it is red; second, it is chiefly noise; thirdly, a good many crackers are only fizzles.

As regards the liability to burn out, and the dangers therefrom, I can only say that from over 600 converters of all sizes from 5 to 50 lights each, in an experience extending over 12 months of constant service night and day without any stop, we have had but three actual cases of burning out, two of these being 5-light converters, and one being a 50-light converter. The two 5-light converters were simply slowly roasted out from overloading, until finally the insulation on the primaries was charred through, when the fuses blew out instantly, and all was over. In one case the customer had been attracted by the converter singing, and was standing looking at it when his lights suddenly went out, and he had to go into a neighbor's store to know whether the trouble was in his lights only, or with the main circuit. The 50-light converter suffered in the same way, having nobly endeavored for some two days to run 120 lights. It was one of three on a section of secondary mains, and the lineman who had been sent out to examine them owing to complaint to us of poor light, reported that two of them were all right, as they were cold, but that one of them was bad, as it was very hot, and preparations were being made to change this converter, when a message was received from one of our customers that the "stove on the pole" in front of his place was smoking.

Investigation showed that both plugs in the other two converters were blown, and the only reason that this one had not followed suit was the fact that some ingenious gentleman had made them of copper. We have had three cases of defective converters; that is, converters with a wire broken inside, or short circuited, so that the moment that the current was put into them, they would blow out all the fuses, and if new fuses were put in, they would again immediately blow, but the men in these cases of course immediately returned them to the shop for examination; that is to say, out of the 600 converters, we have actually had to remove or repair one per cent. in actual service, and I submit that on a total converter capacity of 17,000 lights, this is a very good proof that these converters are well made and not dangerous.

In all of our experience, we have not had one single case of connection between the primary and secondary, or the primary and the shell of the converter, even in the case of the burned out converters, and we had just a few days ago the first case of a connection between the secondary and the shell of the converter, and this last was found upon examination.

We started with the idea that it was better in cases where we had from the number of the lights in a building to use more than one converter, to bank them; that is to say, connect all the primaries and all the secondaries in multiple, and distribute from this 'bus wire, but two or three peculiar experiences have led us to change our plans, and never to do so if it can be easily avoided. We had two or three unfortunate cases where one converter of a bank for some unknown reason would blow its plug, thus overloading the others, then, perhaps, another would give way, and thereafter it was a race as to which would blow its plug the quickest. It is not calculated to make one feel comfortable to have 400 lights in a theater go out at once, just as the curtain was about four feet from the stage, in the beginning of the third act, yet this was our experience last Christmas day. We had the converters fused up and running in half an hour, but next day the same thing occurred, though the gas man seeing the lights dim down was quick enough in shutting off his different circuits to stop three or four converters, which gave him lights enough to pull through. We have cut this building up, and each converter now carries its own load with the result of our detecting one of them which for some reason unknown always tried to do more than its share of the work, but while we have marked it, we have not troubled to change it, as, working singly, it does its work well. We have had another case of the same kind in another bank of converters, which have also since been cut apart, and we found the trouble arose from a poor connection which heated up the fuse to melting point; yet, as we have in the City Hall two banks of 13, 10-light converters each, and in the Union Station a bank of 25 10-light converters and 8 20-light converters, which have never had the current off them for nearly three months, and have never had a single converter of all these blow its fuses, we cannot say that this result would always or even generally obtain; but as the object of banking is primarily to prevent the total extinction in case of one converter going out, and as this is better attained by the judicious running of the secondary circuits, we prefer keeping the converters separated.

For the secondary wiring in the buildings we need lay down no laws. The rules governing this are too well known to need any repetition. One advantage of the alternating system, which was first brought to my attention by one of our wiremen, is the fact that wires carrying the alternating system do not blacken the surface on which they run. We have in our station circuits of direct and alternating currents side by side, put up at the same time, on a ceiling painted in very light colors, and which have been burning the same number of hours. The paint under the direct current wires is very dirty, in the usual style, and the wires themselves are covered with black deposit, while the alternating current wires, and the ceiling on which they lie are as clean as when put up.

There yet remains one point on which I wish to say a few words, and it is a subject of the greatest importance. Now that the alternating current distribution is a pronounced success, there is no reason why the places of all others where incandescent light is most desirable, namely in residences, should not enjoy the advantages and improvements from which they have been hitherto debarred by their distance from the usual centre of distribution, and it is when we bring electricity into the dwelling house, where it will be daily and hourly needed and handled by women and children, that we realize how absolutely necessary it is that we use anything and everything that can tend to make safe its introduction and manipulation. Of course, the first and second of these are, good insulation, better insulation, and best insulation; but besides this, there are other points to be considered, and one that seems to be worthy of very careful consideration, and the fullest discussion, is that which has been more than once suggested, namely, the making of permanent ground connections with the secondary wires. The object of this is, of course, that should a leak occur at any point between the primary and secondary, the current being already grounded, will render it impossible for any one to receive a shock by touching the secondary and at the same time making an earth connection. When I first considered this question, I said in my haste that such was not a proper course of action, as one is simply provoking a ground at some other point, and seeing the careful insulation of the converters we use, I could not see any danger of a leak across, and I have considered and heard some discussion both pro and con, and for this purpose I should like to hear the most bitter partisans on either side, that we may get from them every little weakness on either side of the question brought out.

In a paper like this, it is impossible to do more than to give the merest sketch of the subject, but I trust that what I have said may be the means of inviting discussion and inquiry, for it is only by this means that we can arrive at the true facts of any case, and, as we all know, the electric light industry has suffered more than tongue can tell from the general ignorance of its dangers and requirements, which hindered and injured its early introduction into this country, and which led to the spending of so much good money on plants and wires which were not merely insufficient, but absolutely dangerous.

Now that we have taken, as it were, a new departure and entered into a new era of progress, let us not fall into the same errors which marred the early history of our business, but strive with might and main, by discussion and interchange of experience, to make each new installation another stride towards perfection in what I think is undoubtedly the greatest achievement of the age—the distribution of electricity by alternate currents.

ELECTRIC MOTORS.

BY DR. G. A. LIEBIG, JR.

THE development of the electric motor from its primitive form up to the present state of advancement and usefulness has been similar to the growth of nearly all of those great discoveries, which have proved themselves at first so adaptable and then so necessary to the wants of every day life.

The history of the motor is a very remarkable one, not only as a story of rapid improvement but also because its first chapters belong to recent times.

We can now ask ourselves, not without some astonishment, why it happened, seeing that the laws of the conservation of energy were so generally accepted, that the reversibility of the dynamo and motor was so lately discovered. It is quite true that the first motor was built many years ago, but for a long time even after the dynamo had undergone a very marked improvement, the motor was not turned to practical account. In other words, dynamos and motors have all along been kept distinctly apart, and even to-day there exists sometimes a certain indefiniteness about their relation.

We know that the general term "dynamo-electric machine" includes not only generators of electricity, but also appliances for converting electricity into other forms of energy, and that all the mathematical formulas which have been applied to the dynamo as a generator of electricity are equally as applicable to the dynamo when viewed as a source of motive power. The only changes necessary in our formulas relate to the algebraic signs of certain symbols.

The feature of reversibility is of extreme importance, and means that any rule of construction or of design that tends to make a dynamo machine an efficient apparatus will give identical results when used in connection with a motor. Other considerations may present themselves, questions of speed and output per unit weight of material may arise, and these may be different in the two cases, but they are of a mechanical or at any rate secondary interest, and in no way affect the mathematical considerations. In what follows, therefore, we shall use the term "dynamo-electric machine" to designate, unless otherwise specified, either a generator of electricity or a dynamo reversed, *i. e.*, a motor.

In order to give an intelligible review of the work done on dynamos, and prepare the way for a few considerations which will follow, it may be well to describe briefly the component parts of a dynamo-electric machine, and refer to the purposes for which they are intended. In every dynamo we must have a combination of the following elements:—

(*a*) An iron body or frame work constituting the magnetic limbs. This is always wrapped over a certain portion of its length with insulated copper wire and its purpose is to produce between its ends or polar surfaces a region of magnetic force.

(*b*) A series of coils of copper wire generally wound upon a subdivided mass of iron, and capable of revolution about an axis in such a way as to make each coil pass successively before the polar surfaces of the magnetic limbs. This is called the armature, and is always so placed that it helps, with the magnets, to form a nearly closed magnetic circuit of iron.

(*c*) A commutator, which is merely the ends of the armature coils brought to one side, and which revolving with the armature effects a change in the direction of the currents formed alternately plus and minus.

(*d*) Several brushes or collectors, usually two in number, consisting of pieces of metal which press upon the segments of the commutator, and which are in metallic communication with the terminals of the machine.

In general, the armature revolves between the poles of the electro-magnet; but in some machines, notably those intended to furnish alternate currents, the armature is stationary, and the magnet coils themselves revolve. This is however immaterial, inasmuch as what we have to consider is the relative motion of the parts of the machine, not their absolute movements.

It appears, therefore, that the dynamo machine since it consists, broadly speaking, of an electro-magnet and a revolving coil of wire is a very simple piece of machinery, yet it has taken years of hard labor and patient investigation to evolve from the spinning disc of Faraday the dynamo of to-day.

There is a feature in the history of the dynamo which must appear remarkable to every one thinking of the subject. When we remember how much attention has been directed to dynamo machines, not only by practical but by scientific men, and recollect that all the materials for a complete theory of the dynamo have been for several years at hand, we are inclined to wonder at the absence of such a theory. Even to-day no complete theory exists, though we are in an immeasurably better position in this respect than we were five years ago. For what we know now in so far as it is immediately applicable to dynamos, we are mainly indebted to the labors of Clausius, Hopkinson, and a few others. It is sometimes claimed that the theory of the dynamo has been seriously crippled by the want of sufficient knowledge regarding the law of the electro-magnet, namely, the law connecting magnetic force with the magnetism thereby produced in magnetic bodies. If we admit that an empirical formula is required we must admit the justice of the claim, because no accurate expression of this kind has ever been originated. But we shall see that it is by no means necessary to depend upon empirical laws; all that we require are the curves of magnetism, and these have been before the world for years.

However, we now possess the results of a new series of investigations as to magnetism and a magnetic permeability undertaken at home and abroad, among which the most important are those of Hopkinson, Ewing, Rowland, Warburg, etc. These results, in connection with the work already referred to, make it possible to calculate to a close approximation, at least for certain forms of machines, just what any given dynamo will do when we know besides its dimensions and configuration the kind of iron used in its manufacture.

The words magnetic permeability used above, and which enter so frequently into dynamo calculations are defined by Maxwell (vol. ii, page 50) as the ratio of magnetic induction to magnetic force. It is also called magnetic inductive capacity corresponding to specific inductive capacity in electro-statics.

Following out an analogy in a different direction, it sometimes happens that magnetic permeability is called magnetic conductivity or resistance, the idea being to express the varying resistance offered by a given body to the production within it, of "lines of induction," as the lines of flow are opposed by a porous solid through which is forced an incompressible liquid. Further we know (Maxwell, vol. ii, p. 51), that the magnetic induction is related to the magnetic force in exactly the same way that current is related to electromotive force; namely, we have,

$$B = \mu H \text{ and } C = K E$$

where μ is the permeability and K the conductivity. But the analogy is in a sense imperfect, for whereas K is a constant, in so far at least as it is absolutely independent of the current flowing (leaving all heating effects out of consideration), μ is by no means a constant, but depends not only on the present state of the material in reference to the induction within it, but also upon its previous magnetic history. Thus μ is a variable quantity, and for magnetic bodies grows less and less as the magnetizing force increases. We can, therefore, regard the analogy between B and H on the one hand, and C and E on the other, as holding good only when H is a very small quantity.

In the calculations applied to dynamos, it is extremely important to know the distribution of magnetism over the polar surfaces of the electro-magnets, that is the number and direction of the lines of induction from pole to pole.

A solution of this problem can be arrived at mathematically in an approximate way only, and then, as a rule, by the consideration of what takes place in the least complex forms of surfaces.

To attain certain ends the graphic method may be applied, either roughly by the use of iron filings, or more carefully by the employment of a small magnet suspended by a silk fibre. By observing the positions assumed by the magnet when freely suspended in different regions of the magnetic field, we can form some idea of the form of the field. For we know that the direction given by the magnet coincides with the resultant direction of the magnetic force at that point (the needle being supposed so small as to exert no disturbing influence) and also that the relative number of lines of force in a small space surrounding the point measures the relative field intensity. The positive direction of the lines of force may be taken as from the north pole to the south pole, both outside and inside the magnet, and they are related to lines of induction in this way: outside the magnet they coincide; inside the magnet they are in opposite directions. This amounts to saying that the lines of induction are continuous, whereas the lines of force are not.

Other methods of measuring the field intensity of dynamos have been proposed, such as the magnetometer method. The results so obtained are however inaccurate, and indeed the method cannot be applied at all when the armature is in place. Nor can the very simple pendulum method devised by Sir William Thomson be applied, because the air space between armature and magnets is too small. It can of course be used by removing the armature, and it has the advantage of giving results directly in absolute measure.

Unfortunately, measurements obtained under these circumstances do not give us a reliable basis for calculations, inasmuch as the form of the magnetic field is strongly influenced by the presence or absence of the armature, at least when it contains iron. It may be remarked that magnetic distribution is exactly analogous to electric distribution, especially in the case of dielectrics, and that the geometrical form which influences the latter plays almost as important a part in the case of magnetic distribution.

We are aware that the density of electricity on a given portion of a charged body depends upon the shape of the body and also upon the presence near it of other charged bodies. The same laws of surface density determining the so-called leakage of lines of force obtain in the case of magnetism. In almost all dynamos the pole-pieces have necessarily somewhat sharp edges, and the number of lines of force obtained per unit area is probably greater at the edges than over the remaining polar surfaces. This number is subject to a change when the armature is in place, and to a further modification when the armature revolves, on account of the change in the direction of the axis of magnetization of the latter. These considerations show us that any system of measurement which will give useful results must be of such nature as to be applicable to the dynamo when in working order. The ballistic

method fulfills these requirements; it is sufficiently accurate, and besides involves no special difficulty. We have simply to surround that part of the magnetic circuit of which we want the induction with one or more turns of copper wire connected with a ballistic galvanometer and observe the throw of the galvanometer needle when the magnetism is reversed or reduced to zero.

It is always better to observe the elongation of the galvanometer needle due to a reversal of magnetism. An uncertainty always attends a reduction to zero owing to the phenomenon of residual magnetism. The galvanometer having once been calibrated in absolute measure, we can from the throw of the needle calculate the value of the total induction within the wire, and the magnetic force is known from the data of magnetizing current and number of convolutions. The experiment is repeated for the different parts of the machine, so that we finally obtain the value of the induction throughout the entire magnetic circuit. Suppose now that we have measured the field intensity and have a value of the induction per unit area; we can, by Faraday's law, calculate the E.M.F. which would be set up in a conductor moving in any manner in the field. The law is this: The E. M. F. produced in a conductor moving in a magnetic field is equal to the rate of cutting the lines of force. If the conductor forms a closed circuit, the E. M. F. depends upon the area of the circuit. Hence, in order to be able to determine the E. M. F. produced in an armature, say, we must know the area of the coils of the armature, the strength of the magnetic field, and the velocity of rotation. Call the total number of lines of induction (flow of force) passing through the armature N and the current γ then, we have for the force x acting when the circuit is displaced through the distance $d\,x$, by the principle of the conservation of energy (Maxwell, vol. ii., p. 137):

$$X = + \gamma \frac{d\,N}{d\,x}.$$

Hence, the movement is aided or resisted according as the number of lines of induction passing through the armature is increased or diminished by the movement. The work done during the displacement, is

$$X\,d\,x = \gamma\,d\,N,$$

and if the number of lines of induction is changed from N to N, we have for the whole work:

$$\int X\,d\,x = \gamma\,(N' - N).$$

Let us divide both sides of the equation by $d\,t$, and we have:

$$X \frac{d\,x}{d\,t} = \gamma \frac{d\,N}{d\,t}$$

as the rate at which work is done. But $\frac{d\,N}{d\,t}$ is the rate at which the lines of force are cut by the moving conductor and is equal to the amount produced in that conductor. We have, therefore, for the rate of doing work—the activity:

$$\gamma\,e = \frac{E - e}{R}\,e,$$

the well-known expression for the activity of the motor.

We shall now simply refer to the investigations of Clausius,[1] and Hopkinson,[2] as their work though differing in character is of extreme importance. The theories published by these two scientists are distinct and characteristic of the two ways of regarding magnetic phenomena. Hopkinson's method is based upon two fundamental laws of electro-magnetism; one law expressing the relation between currents and magnetic force, the other a condition which always holds for magnetic induction. They are as follows: The line integral of magnetic force around any closed curve is equal to zero, unless the curve surrounds a current, in which case it becomes four π times the total current through the curve; the other is the equation of continuity applied to magnetic induction, which means that a line or tube of induction cannot end at a point in space. According to the last law, therefore, if we find that the magnetic induction has different values in the different parts of the magnetic circuit composing the dynamo, we know that there has occurred a leakage through the air. For instance, the total induction through the armature in every dynamo is less than the total induction through the magnet limbs; the excess has, therefore, passed beyond the limits of the iron body into the air from pole to pole.

The two laws just given furnish a means of constructing the characteristic curve with considerable accuracy, *a prior*; that is, the curve showing the relation between electromotive force and current, for the total induction nearly proportional to the induction through the armature at a given speed determines the E. M. F. generated. The data required for calculating the line integral of magnetic force are: first, the general configuration of the dynamo; specification of the kind of iron used; the sectional areas; the lengths of the different parts of the machine; the magnet limbs; armature yoke pole-pieces; and from these the "magnetic lengths" can in general be estimated. The variables chosen are the total induction through the armature and the current around the magnets. Certain co-efficients occur in the equations expressing the relation between the induction in the armature and that in other parts of the dynamo; they are approximately constant, and can be estimated when their values for a machine of given form are once known. Hopkinson's equation can be thrown in the form,

$$\Sigma\,l\,f\left(\frac{v\,I}{A}\right) \quad 4\,\pi\,n\,c,$$

Σ denoting summation. I is the induction through the armature and the function f depends upon the qualities of the iron in the machine. In a machine in which experiments were conducted by Drs. J. and E Hopkinson, the difference between the induction through the armature and magnets amounted to about thirty per cent. As an indication of the power of the method and the accuracy with which results obtained from one machine can be applied to dynamos of every different form, it may be recalled that the characteristic curve of the "Manchester dynamo" was constructed before the machine was built, and was found to require no correction afterwards. In this case the dynamo possessed not only an entirely new form, but was also compound wound.

The theory of Clausius is founded upon considerations of a totally different character, and is undoubtedly less readily adaptable to practical manipulation. The theory is based upon Ampere's well-known laws of the action of currents upon conductors; an action which is supposed to take place at a distance and not through an intervening medium, as explained by Faraday, Maxwell, Thomson, and others. Clausius expresses in his fundamental equations the mutual potential of the currents of the dynamo upon one another, and to determine the magnetic moments of the magnets and armature he adopts, with, however, considerable unwillingness, Frœlich's formula of induced magnetism. This formula has been extensively used, and generally under the form:

$$M = \frac{a\,i}{1 + b\,i}$$

in which a and b are constants and i the current. There has always existed a more or less marked opposition to Frœlich's formula, as not giving results in accordance with experiment though the curve it represents is a practically straight line near the origin. Investigation has shown, and Hopkinson has called attention to the fact that the curve should have a point of inflection at the origin, and hence it must be slightly concaved downward (that is, toward the axis of abscissae) during the first part of its course.

Clausius has remarked that it would be better for a dynamo if the core of the armature remained stationary while the coils alone revolved. Mechanical difficulties, of course, preclude the possibility of such an arrangement; yet, we shall see that other considerations support the views of Clausius. In the case of two machines, one used as dynamo and one as a motor, the author has shown that the velocities of rotation necessary to secure maximum work are not in the ratio of one to two as generally believed, but approach this value as the speed of the generator is increased. This, however, refers to the condition existing when the work done by the generator, is not limited. When the work is determined, he shows that there can be no relation between the speeds of the machines in order to give a maximum of work done by the motor.

Another theory, though scarcely a distinctive theory, has been advanced by Dr. Frœlich, and much work of a theoretical character, besides that mentioned in reference to dynamo-electric machines, has been done; but the most important have been referred to.

There is one point which may as well be mentioned at this place about dynamo construction, which seems to have been the origin of exceedingly contradictory opinions.

It is in reference to the position which the coils of wire should occupy on the field magnets. In some cases, we find the coils heaped up toward the middle of the magnets; in some cases, toward the pole-pieces, while in by far the majority of machines the coils are evenly distributed along the whole length.

Theoretically the latter system of winding should be just as effective as the others, and being less complicated, should be used on that account. Professor S. P. Thomson recommends in his work that the layers should be most numerous around the middle of the magnet limbs; in support of which view, he calls attention to the form and number of lines of force from a straight bar magnet in which there is a leakage all along the bar from pole to pole.

The conclusion, however, is unwarranted and the comparison valueless, because in dynamo machines we are dealing with as nearly as may be closed magnetic circuits, and because the dis-

1. J. Hopkinson, Proc. Roy. Soc., 1888.
2. Clausius, Phil. Mag., 1888.

tribution of magnetism under such circumstances is entirely different from the distribution in bar magnets, whether long or short. The remedy for leakages which do occur is to be found not in the peculiar shape of magnet coils, but in the qualities of iron and lengths and sectional areas of the magnetic circuit.

The question of the regulation of motors now demands our attention, and we shall have to consider the methods adopted to meet the requirements of the two systems of electric distribution now in vogue. We can say two systems, because up to the present, motors have not been successfully used on alternating current circuits whatever may happen in the near future. The two systems known as the constant current or arc light and constant potential or incandescent lamp system, necessitate methods of regulation in motors, which are entirely different. For constant potential work we can use either a shunt motor or a "compound wound" machine. In the latter, the main or shunt coils are in shunt with the armature and series coils, or with the armature alone, the series coils being wound in a direction opposite to that of the main magnetizing coils. This system seems to have been first proposed by Messrs. Ayrton and Perry, and is described at some length in Thomson's book on Dynamo-Electric Machinery. Bosanquet (Phil. Mag. vol. xv., p. 275) arrived at a law of winding similar to Ayrton and Perry's, but deduced from entirely different considerations. The elementary theory of machines of this type is too well-known to require special attention. It is sufficient to say that machines so constructed regulate very perfectly (that is, run at a practically constant speed), and have been extensively used. It is however by no means necessary to employ a differential winding of field magnets as has been mentioned in order to secure regulation. The same results are attained by the use of a simple shunt arrangement, provided there exists a certain relation between the resistances of the shunt coils and armature. Indeed, many constant potential dynamos with excellent regulation have already been made in this manner, and motors on the same principle are rapidly coming forward.

It has been stated that compound wound motors (that is, shunt motors, with series regulating coils) will not run at an invariable speed when the load changes if supplied with a constant current, unless the speed is such as to reduce the efficiency to 50 per cent. or less. The statement seems inaccurate; an efficiency of 50 per cent. having nothing to do with the regulation, as we shall see by examination.

Let us consider the matter for a so-called "long shunt" motor. Call now:

E, Electromotive force of supply.
e, Counter E. M. F. developed.
R, Resistance of armature.
r_s, Resistance of shunt coil.
r_m, Resistance of series coil.

Then we have for the rate at which energy is supplied to the motor:

$$\frac{E(E-e)}{R+r_m}$$

and for the rate at which work is done by the motor:

$$\frac{e(E-e)}{R+r_m}=W.$$

Regarding now both with W and E, as functions of the counte E. M. F., we have by differentiation:

$$\frac{dW}{de}=\frac{E-e}{R+r_m}+\frac{e}{R+r_m}\left(\frac{dE}{de}-1\right)$$
$$=\frac{E-2e}{R+r_m}+\frac{e}{R+r_m}\cdot\frac{dE}{de}$$

If the potential of supply is constant, then $\frac{dE}{de}=0$, and the equation reduces to its first term. In this case, we see at once that the differential coefficient of W, with respect to e is positive or negative, according as $E > 2e$ or $E < 2e$. This means that as the load increases we can keep that speed constant by diminishing or strengthening the field, provided the efficiency is greater or less than 50 per cent., and this is well known. Suppose now that E is variable but that the current is constant; then we have:

$$K=\frac{E}{r_s}+\frac{E-e}{R+r_m}.$$

Differentiating, we have:

$$\frac{1}{r_s}\cdot\frac{dE}{de}+\frac{1}{R+r_m}\left(\frac{dE}{de}-1\right)=0;\text{ or}$$

$$\frac{dE}{de}=\left(\frac{1}{r_s}+\frac{1}{R+r_m}\right)=\frac{1}{R+r_m};$$

or putting $\rho=R+r_m$, we obtain:

$$\frac{dE}{de}=\frac{1}{\rho}\cdot\frac{r_s\,\rho}{r_s+\rho}=\frac{r_s}{r_s+\rho}.$$

Substituting in our first equation this value of $\frac{dE}{de}$, we get:

$$\frac{dW}{de}=\frac{E-2e}{\rho}+\frac{e}{\rho}\cdot\frac{r_s}{r_s+\rho}$$
$$=\frac{E(r_s+\rho)-e\,(2r_s+\rho-r_s)}{\rho\,(\rho+r_s)}=\frac{E}{\rho}-\frac{e}{\rho}\left(\frac{2\rho+r_s}{\rho+r_s}\right)$$

and, therefore, $\frac{dW}{de}$ is positive or negative; that is, the rate at which work is done increases or diminishes as e increases, according as:

$$E > \text{ or } < e\,\frac{2\rho+r_s}{\rho+r_s}$$

or, according as the efficiency:

$$\frac{e}{E} > \text{ or } < \frac{\rho+r_s}{2\rho+r_s}.$$

This quantity, in the kind of motor under consideration is nearly unity, because the shunt coils have a resistance very great compared with that of the series coils or armature or both together.

The question of an efficiency of 50 per cent. does not therefore enter.

A better way to arrive at some knowledge of the regulation is to introduce an expression for the torque into our equations.

If we denote the speed by n, and call T the torque or work per turn, we have for the rate at which work is done in the motor:

$$W=n\,T=\frac{e\,(E-e)}{R+r_m}$$

This is usually called the activity. Differentiating this we have

$$n\frac{dT}{dn}+T=\frac{1}{R+r_m}\left(e\frac{dE}{dn}+E\frac{de}{dn}-2\,e\frac{de}{dn}\right).$$

or substituting for T its value in terms of E and e and rearranging, we have for our fundamental equation:

$$\frac{dT}{dn}=\frac{1}{n\,(R+r_m)}\left(e.\frac{dE}{dn}+(E-2e)\frac{de}{dn}-\frac{e(E-e)}{n}\right).$$

Let us examine the case of a shunt motor supplied with a constant current K, and writing as before:

$$K=\frac{E}{r_s}+\frac{E-e}{R},$$

and assuming that the magnets are far from saturation, we have:

$$e=\text{const.}\times n\,N\frac{E}{r_s}=C\,n\,N\frac{E}{r_s};$$

N being the number of turns of wire in the shunt magnetizing coils, and C a constant. Solving for E and e, we obtain:

$$E=\frac{-r_s\;RK}{CnN-(R+r_s)};\quad e=-\frac{CnNRK}{CnN-(R+r_s)}$$

$$\frac{dE}{dn}=\frac{r_s\,RKCN}{(CnN-R-r_s)^2};\quad \frac{de}{dn}=\frac{CnNK(R+r_s)}{(CnN-R-r_s)^2}.$$

Substituting these values in our previous equations, there results:

$$\frac{dT}{dn}=C^2N^2RK^2.\frac{CnN+R-r_s}{(CnN-R-r_s)^3}$$

an equation of the second degree in n, and representing the rate of change of torque. As R is too small to affect the sign of the fraction, it follows that $\frac{dT}{dn}$ is always positive; that is, the torque increases as the speed increases.

Furthermore, as $\frac{dT}{dn}$ is a function of n, the speed, the rate of change depends upon the speed itself, being greater for low speeds than for high speeds. However, the equation is only true within a limited range, for at great speeds, the magnets would be saturated, though the armature reaction would practically change but little.

If we now regard E constant and suppose the motor to be a series motor, we have:

$$e=CnM.\;\frac{-e}{R};$$

M being here the number of turns in the series magnetizing coils. This may be written:

$$e = \frac{C\,n\,M\,E}{R + C\,n\,M}.$$

From which we obtain:

$$\frac{d\,e}{d\,n} = \frac{R\,C\,M\,E}{(R + C\,n\,M)^2};$$

and substituting as before, we have at once:

$$\frac{d\,T}{d\,n} = -2\,\frac{C^2\,M^2\,E^2}{(R + C\,n\,M)^3};$$

which is of the third degree in M, but negative. Hence, the torque diminishes as the speed increases, and as before $\frac{d\,T}{d\,n}$ is different for every value of n.

Suppose, now, that we have a series motor supplied with a constant current K. Here,

$$e = C\,n\,M\,K \text{ and } \frac{d\,e}{d\,n} = C\,M\,K = \frac{d\,E}{d\,n};$$

$$\frac{d\,T}{d\,n} = \frac{1}{R\,n}\left(E - e\left[\frac{d\,E}{d\,n} - \frac{e}{n}\right]\right) = \frac{1}{R\,n}$$

$$= [R\,K\,(C\,M\,K - C\,M\,K)].$$

Or,
$$\frac{d\,T}{d\,n} = o.$$

That is, the torque being independent of the speed is a constant. Finally, let us consider the case of a shunt motor on a constant potential circuit. As before

$$e = C\,n\,N \times \frac{E}{r}; \text{ and } \frac{d\,e}{d\,n} = \frac{C\,N\,E}{r_s};$$

and by substituting and rearranging, we have:

$$\frac{d\,T}{d\,n} = -\frac{C^2\,N^2\,E^2}{R\,r_s^{\,2}} = -\text{ constant.}$$

In the last two cases, therefore, the rate of change of torque with speed is a very simple expression. For a shunt motor supplied with a constant potential current, the regulation may be excellent, provided $\frac{d\,T}{d\,n}$ is a large quantity, but in no other cases have we even an approximate regulation. For constant current work we require a series machine, and the best method of regulation to be applied to it, so far devised, is a mechanical governor, which automatically changes the number of ampere turns in the field corresponding with the load on the motor. Such a governor need waste but little energy and may be as continuous in its action as desired.

Of the losses which occur in motors, we have in all cases to take account of those which are due to the following causes:—

First.—Heating of wires equal to:

$$C^2\,R \text{ or } \frac{E^2}{R}.$$

Second.—Foucault currents in pole-pieces:

This depends upon the number of armature sections; that is, fluctuations of current, and is generally small unless the Pacinotti form of armature is used.

Third.—Foucault currents in armature. This depends upon (strength of field)^2, and in the modern laminated armature may be neglected.

Fourth.—Reversals of magnetism of armature equal to $\frac{1}{4\,\pi}$ (coercive force) $\times$ (maximum induction) $\times$ n $\times$ (volume). That is, it depends upon (strength of field)^2 and velocity of rotation. No amount of subdivision of armature core can affect this, except in so far as it modifies the total volume of iron in the armature. However, a low-magnetic resistance is necessary, and to secure this the armature must contain much iron. It is on this account that an advantage from a stationary armature core would be derived

Fifth.—Momentary short circuiting of armature coils, depending upon coefficient of self and mutual induction of armature coils and strength of field.

Sixth.—Finally, friction in bearings. This is difficult to estimate. If the belt is such that Morin's principle holds true, losses due to friction are constant.

In self-regulating motors, the speed is constant or nearly so; hence, the causes of the dissipation of energy are confined to variable currents in the conductors and to changing field strength.

These in compound wound and constant current motors depend upon the load, but as we see at once are practically constant for a properly made shunt machine. For a pure shunt machine, therefore, the efficiency, provided the speed does not change, is independent of the load.

Before bringing to a close the few remarks which I have ventured to make on the subject of electric motors, it may be interesting to give a few facts regarding the growth of motor industry, and to point out how various are the demands made upon these machines for manufacturing and commercial purposes.

Through the kindness of the Executive Committee of the National Electric Light Association, I am enabled to bring before you a few figures which will, I trust, act as an incentive to increased activity in this direction.

The committee has addressed circulars to 234 companies engaged in electric lighting with the following questions:

1. Number of motors in operation.
2. Size of motor.
3. Maker's name.
4. Current used.
5. Charge per h. p. per month.
6. Charge per month per arc and incandescent lamp.
7. Results as to service.
8. Customers' opinions as to power and service.

As a result, answers have been received from fifty-six companies, and from these replies the following statements have been gathered.

Average charge per h. p. per month, 10 hours run..	$10.00
Average charge incandescent lamp, 10 hours run....	13.50
Average charge per arc lamp until 10 o'clock.......	9.83
Average charge per arc lamp until 12 P. M..........	13.00
Average charge per arc lamp all night..............	22.00
Highest charge per h. p. per month.................	15.00
Lowest charge per h. p. per month..................	6.25
Highest charge per incandescent lamp per h. p......	21.00
Lowest charge per incandescent lamp................	11.25

The motors supplied with current have been used for the following purposes:—driving ventilating fans, collar and cuff machines, printing presses, various apparatus in repair shops, sewing machines, coffee mills, machines in gun shops, sausage machines, elevators, lathes, pumps, dams, ice-cream freezers, organ bellows, appurtenances in laundries, etc., etc.

Sizes of motors have ranged from ½ to 15 h. p. 26 companies have supplied motors from arc light circuits; 14 from arc and incandescent, and 16 from incandescent lamp circuits alone. In 34 cases, subscriber owns motor and pays per month for current. In other cases, companies own motors and charge rental for same.

Companies are endeavoring to have subscribers own motors in all cases, and pay for the current. Electric light companies are satisfied and willing to enlarge the business. Customers' reports are also very satisfactory.

Although the number of cases cited above is small, it is still enough to show us how effectually the motor can supplant the steam engine, especially for those purposes for which the power required is small and under complete control. The opinion of those who have used electric motors indicates that they do their duty well, and encourages us to expect a brilliant future for this branch of applied electricity.

ECONOMIC VALUE OF STEAM PRESSURE RECORDS.

BY JARVIS B. EDSON, M. E., OF NEW YORK.

THE engineer of the present century begins his operations based upon the pressure of steam he is capable of maintaining in his steam boiler. From this he extends his calculations and elaborates his plans for the prosecution of his work. It matters not what the problem may be, whether it is the grain to be threshed, grist to be ground, hills leveled or mountain pierced, ore raised or office reached, ocean plowed or continent crossed, the same agent performs them all. The tropical fruit while rushed to a northern market is also cooled by it, and the plethoric meat of the western plain is refrigerated during its transcontinental run, till finally we see the coal transformed into heat, then into steam and manifesting itself in work, in its production of coal exemplifying the beautiful law of the conservation of energy and making us thankful for the birth of steam. At present the civilized world is lighted by it and searching for one greater than Faraday who shall give us a substitute and sound the death knell of steam. So, meanwhile, we reconcile ourselves to the loss passing up the chimney and stand aghast when the boiler "lets go," scattering death and destruction in its wake, and simply conclude with a verdict of "nobody to blame."

Investigation and scientific study have done much however, both for the construction and the safe and economical management of steam boilers. Mystery no longer accounts for boiler explosions, for the conclusion has been reached that "the cause of

such accidents can be wholly prevented and controlled," and ignorance is becoming dethroned in her management, to make way for the more intelligent methods of boiler management. The men from our colleges and technical schools demand the facts that they may proceed to their conclusions intelligently. Not theirs, to view the 135 victims of a "Westfield" explosion, with "nobody to blame," for it is not they, who beat upon pans and blow horns to scare the "devil" when the sun darkens. The solar eclipse to them was calculated upon and predicted in advance of its coming. Their verdict will always be: somebody is to blame, explosions are caused by ignorance or neglect.

And so with economy, for to them, the furnace will be a sort of gas retort, and the burning of coal a scientific study. To them, the boiler, a giant struggling against almost equal odds, harrassed by conflicting expansions and contractions, constant and varying strains, attacked by corrosion and injured by scale. They will know it is a magazine of enormous power in which each cubic foot of water has the explosive energy stored within it of a pound of gunpowder, and to them eternal vigilance will be the price of safety. Certainly then it does appear strange, that for such a charge we should employ cheap labor, that the most ignorant man about the establishment is the favorite fireman. For my part it is incomprehensible how either practical men, or those of the usual business sagacity can feel willing to discount the chances against such a course.

Nevertheless, the engineer of to-day is confronted with these conditions, and the safety and economy of his "plant" become of imperative importance to his success. In these two connections then, I desire for a few moments the indulgence of your attention, with a view to submitting to your judgment, certain facts bearing upon the importance of providing some method whereby a surveillance over the steam pressure may be had, for accurate and full information as to the management of our boilers should always prove useful and interesting.

Upon the question of safety, it requires no demonstration to prove that whatever impairs the boiler's strength or durability should be prevented.

To make such prevention possible, however, presupposes the means whereby the preventable occurence may become known. If, therefore, fluctuating or excessive steam pressures are injurious, how are we to be made aware of their occurrence?

Obviously but one method exists, and that is the resort to automatically steam written records of them, and from which we can determine the departure from conservative limits. Assuming that the ordinary steam gauge, which only indicates the pressure, at the instant, is entitled to the great confidence bestowed upon it, it undeniably lacks the ability to afford us any more information, as to the pressure of the previous moment than the proverbial dead man, who can tell no tales. In fact for many years, owing to sharp competition they have been so poorly constructed as to be even dangerous to use—so liable are many to rely upon them for the determination of the pressure they are at the time carrying, even going so far as to adjust their safety valve weights to blow with the gauge. The dials are first produced by different methods in large quantities, all alike, and the springs taken afterwards, which will come the nearest to the "travel" called for by the dial so laid out, whereas, each spring has its own "travel," and its dial should be laid off accordingly, and a suitable price demanded for the article when made, as a cheap and unreliable steam gauge is dangerous, and dear at any price.

When, however, only one of these is relied upon for 20 years, it is apt to be considerably out. Last month I came across one such, in a state hospital which was ten pounds out, and in which case the pipe leading to it was stopped up by dirt, etc., so the pressure rose and fell not with the pressure, but soon after change occurred, as the condensed steam "water" could soak through the obstruction.

Instead, therefore, of relying solely upon the ordinary indicating instrument, whether it be entitled to such confidence or not, common prudence would dictate the employment of more than one gauge, and preferably that the supernumerary should be a recording machine.

The records of steam pressure carried have a large prudential value, for the reason that with their use a fireman must give up his position or do what he is required. For instance, if a careless man lets his steam get too high before he discovers it, and the safety valve does not blow as calculated upon, from any of the causes common in such cases, who other than the fireman will be any the wiser, and when will the remedy for a careless fireman, or faulty or overloaded safety valve be applied.

It is generally supposed to be necessary to first know of a trouble before its remedy can be either determined or applied.

The only way, therefore, to know whether one's boilers are being exposed to excessive pressure or not, is to use a gauge which records the pressure.

Occurrences are constantly taking place under that smooth sounding term "banked fires," which would electrify every hair of one's head if revealed to those who have so much at stake, and think such a fire harmless. A strong fire towards stopping time leaves the boiler setting so hot as to supply sufficient heat for running up the pressure beyond what a cold setting could do. Yet when the fires are once "banked" the man "lets up" on his watchfulness, and generally the boiler is left entirely alone for a long interval. "We never carry steam at night as we 'bank' our fires, and in the day-time have a good careful man around," is an expression common to most steam users, but a few moments will generally convince them that they have assumed a very ridiculous and untenable position. The police of our cities frequently find steam blowing off from boilers under the sidewalk during their night perambulations, and have learned that it means one of those places where they "never carry steam at night," and he routs somebody out in the building or neighborhood to remedy the trouble. One summer, recently, while stopping in a manufacturing town, I heard a shrill whistle blow for two or three hours during the night, and concluded, as I learned the next morning, that it was a low water alarm. The police hunted up an engineer to go to the establishment and give the boiler some water, and fortunately the boiler took the engineer's proferred kindness without getting up and going off and out of shape about it, either.

A case occurred last October, under one of the costliest buildings on Broadway, New York, where fires are "banked" and they "never carry steam at night." It appeared, however, from the recording gauge chart, the next morning, that something had caused the recorder to make a high steam line from a good part of the night, and investigation proved that the night watchman heard a roaring noise when in the top of the building, and concluded that it must be the boiler "blowing" about something, so he clambered down twelve or thirteen stories and found the damper closed and a full pressure on. Of course, it goes without the saying, that if the valve had been fast in the seat, or the weight shifted on the lever from any cause, a first-class explosion would have followed. The boilers are provided with an approved pattern of damper regulator on the main flue, and also have individual dampers on the branches from each boiler leading into the main flue. The individual dampers are of course for shutting off either boiler when not in use. The trouble was caused by the fireman not knowing enough, or forgetting to unhook his automatic regulator connection before leaving for the night, and so when the banked fire and heated walls had radiated sufficient of their heat the pressure of steam closed the damper, and the heat being entirely shut in and no air passage left open to the chimney, and little or no steam being used in the building, "safety valve" was called upon and fortunately did its duty and prevented the steam passing beyond the limit as shown by the chart.

In the same establishment, only two months later, on New Year's morning, the night watchman closed the furnace doors at the usual hours, so the fires would be in better condition for the day fireman when he arrived, but the day man did not arrive until some two hours later than usual, as it was a holiday, and so the steam went up again and startled the neighborhood with the racket for an hour or so. The day man claimed that he told the watchman not to close the doors until a later hour, which the latter denies. Be it all as it may, in both instances the chart, daily submitted to the manager of the property, revealed the occurrences, and brought forth an investigation, resulting in more correct methods of transmitting orders and causing the unhooking of the regulator while under "bank fires," and also in making the night watchman make more frequent visits to the boiler room. Who can deny but that in this instance, their indifferent methods would ultimately have resulted in exploding their boiler had not the recording gauge unmasked the facts and caused the proprietor to set some needed rules in force. If an ounce of prevention is better than a pound of cure the instrument repaid its first cost in these two instances alone.

Self interest should suggest the use of such a safety appliance particularly, inasmuch as all persons are supposed to intend the natural consequence of their acts, for proof of an act, or course of procedure, which was adopted or persisted in to deceive the public or in defiance of its safety, is sufficient proof of the intent to deceive and jeopardize, unless the doer establishes innocence of such intent and knowledge, and the burden of proof rests on him. If, therefore, it be true that no steam boiler "plant" can be conducted as intelligently, economically or safely, without the information and aid supplied by the pressure recording instrument as with it, then proof of negligence can be made out establishing the fact that such a valuable monitor and means of information as the pressure recorder had been rejected, and failure to secure such competent attention may be properly urged in courts of law as evidence of negligence.

Even so important a matter as the amount of pressure applied by an authorized inspector in testing a boiler with hot water, has shown that only an excess of eight pounds was put upon an old boiler which is regularly carrying from 55 to 60 pounds pressure of steam. The record further shows the pressure to have been "jumped on" for an instant and then released, allowing no time for inspection while under the testing pressure of the seams, etc. No satisfactory reason has been obtained so far, for this improper method of testing, but the fact has been established, and so much gained. Certainly more confidence could be reposed in a test where the record shows that the boiler sustained the testing

pressure for five or ten minutes, and during which time the testing engineer could be presumed to have been examining the boiler for evidence under such strain.

Another matter revealed frequently by the recording gauge chart is the habit indulged in by many attendants, called "bottling up steam." The most frequent occurrence of such habits takes place at a few minutes before starting time in the morning, and at noon, and in some cases, just before cleaning fires. Of course, such prejudicial habits are the simple outgrowth of ignorance, concerning the limited amount of steam quantity they can bottle up, and the very small service it can render, compared with the injury such practice, when persisted in, ultimately does the boiler. Aside from this objection, the habit is exceedingly pernicious, because only a few moments neglect would cause the pressure to accumulate, to the point at which the safety valve is supposed to open; then, if it happens to be inoperative, an accident is almost certain to follow. No excuse should be taken in any shape, under any kind of reasoning, for "bottling up steam;" if the generating capacity of the boiler is not equal to the current demand, it cannot be helped by simply bottling up; in fact, it has been my experience that where the record line has been extremely crooked, upon the first introduction of the recorder, the effect of such record has been to cause a much more uniform use from day to day, until the nearest approach to uniformity has been reached, consistent with the vicissitudes of the demands for steam. A steam user once apologized for the appearance of his record, saying that the steam was drawn from the boiler at irregular periods by persons in the mill, and consequently the fireman could not carry any very regular line; that his use of steam was different from that in most places, etc. Noticing, apparently, my incredulity, he asked if I disagreed with him. My reply was "Do you suppose that the steam necessarily falls as low as this record indicates?" In other words, I called his attention to the fact that where a fireman is on the keen lookout for his boiler pressure and water level, he will readily detect the pointer hand of his gauge the moment it begins to rise and fall, and govern himself accordingly. For instance, if he sees the hand indicating that the pressure is falling, he will avail himself of the opportunity to slow down his feed, and perhaps open his damper wider, and if his fires are in prime condition, withold fresh coal for a few moments, then when the onslaught upon his boiler has ceased, and the hand of his gauge is stationary, or starts to move upwardly, he will at once set about to replenish his coal and water, and so have his conditions favorable in a few moments for another attack upon the steam supply. When his steam is raising he can afford to feed and to fire, and his thought should be to have everything in prime condition while he has surplus power and opportunity. Then he would not be caught so badly when these extreme attacks were made upon him. The cause of these extreme fluctuations then, is largely due to the fact of his being unprepared to meet these emergencies, and becoming alarmed when his steam has fallen 20 or 30 pounds, he attempts to get it up by replenishing his fire, as it seriously needs it, with coal, which only tends for the time being to reduce the pressure still more until it has been capable of delivering its gases, ready for combustion. After this little explanation, the proprietor shook his head, and said he had never thought of it in that light, and that he would have to call John to him and have a talk with him. Now the result of this was from that time on, the man's record never fluctuated in the same manner again, and the average steam line maintained was one which showed constant attention to firing frequently in small quantities, and keeping himself in shape to meet these emergencies.

Undoubtedly, the man had to work a little harder at first, but afterwards it was easier when he properly understood the matter and manipulated his fires accordingly. The suggestion to the proprietor was exceedingly valuable. It resulted in the proprietor teaching his man, and mutual regard between them afterwards, because it showed that the man was capable of being taught and also willing to be, and that the proprietor had evidence of the resulting fidelity. The dissemination of knowledge among firemen can certainly do no harm, and when it reaches a man who desires to hold his position and give satisfaction, it will do much good. Men uneducated to the science and what constitutes firing steam boilers, can hardly be expected to use that knowledge which others possess professionally.

Some men will fill a furnace full of coal, so as to have more time to walk around; then after a time up goes the steam pressure, because more steam is generated than is wanted; more heat is generated than is wanted; then the feed water is turned on and the water level run up so as to keep the steam pressure down; the safety valves may blow, or not; the damper is closed; the fires smolder; large quantities of carbonic oxide gas generated up the chimney—and this means an escape of unconsumed fuel, which means dollars and cents. After a while, the fires burn lower, and down goes the steam, helped down, it may be, by another dose of coal, and so we can imagine the final effects on boilers used in such a manner. The position of a fireman may be considered an humble one by some folks, but he is a man for all that, and his pride in what he can do is a stronger spur than anything else. Let him see that you care for what he is doing, and take a careful interest in his work, and let him understand furthermore that his own grading depends upon himself, as established by his records; then you are in a fair way to have confidence in your man, and in your safety, and also feel assured of economy of fuel. But eventually you must pay him what he is worth. If not, some one else will be glad to have him. Suppose for instance, a man who burns three tons a day, is paid two dollars for such service, and in so doing he is wasting as little as 10 per cent. If coal costs $4.50 per ton, the loss will be $1.35 per day, or what is equivalent to paying a man $3.35 per day, who can save this amount; but when amounts of, say, 8,000 tons per month are used, the saving of only 10 per cent amounts to $80 per day, and the small portion of which is offered as a premium to the men who use this coal would go a long way towards saving the remainder of this money. What is wanted is the maximum of steam per dollar's worth of coal; much can be saved by the manner of its use, and it is within limits furthermore to say that, from 5 to 10 per cent, is frequently gotten rid of by firemen not qualified as such and entirely ignorant or indifferent regarding the science of complete combustion. Certainly it is of vastly more importance to a proprietor, both on the score of safety and economy that his fireman shall be a man trained in the art of properly burning the fuel supplied him, than that his engineer shall know, particularly if the latter does not impart the information to the fireman. The practical value, therefore, of the steam record is in this connection that it compells the fireman to give close attention and maintain uniform water level; and uniform steam pressure cannot be had with anything short of the closest scrutiny of the steam gauge, which means economy of fuel and safety as well. The explanation of the charts has given much information touching unexpected occurrences but innumerable other instances might be cited which would only tend to exhibit the surprisingly large number of them possible wherever steam is used, and those facts become more generally known to those who are not at present deriving the information from such instruments. They will be extended, and more careful methods of caring for steam boilers under pressure will be inaugurated ultimately, resulting in not only greater economy of fuel, but in a greater degree of immunity from those disastrous explosions which destroys so many lives and so much property annually.

WHAT CONSTITUTES A GOOD CARBON POINT.

BY G. W. PARKER.

FROM the standpoint of the manufacturer all well baked carbons that are straight, free from cracks and other similar defects, and made from pure material, are good carbons. The electric light engineer will say that no carbon is good unless it will centre properly and give him a reasonably long life with a good light. He is not at all inquisitive as to the method of their manufacture, provided they give such results. But as the manufacturer can go no further than to correct any errors in his mechanical processes, the value of the carbon afterwards depends upon the conditions of its use. Such carbons as are described in the first paragraph will in some currents be satisfactory both as to light and life. In others the light may be brilliant and the life too short, or there may be arcs too short or too long, flaming, or other defects arising from the unsuitability of the carbon to the current, there being no inherent defect in the pencil itself. Therefore, to cover the whole ground of this important inquiry, we should also have the carefully compiled statements of your experience of the behavior of carbons burning in your lamps under varying circumstances. From this, results of great value to both sides might be obtained.

There appears to be no trouble in determining what constitutes a good carbon mechanically, but to you a good carbon means one that will give you satisfactory results in your use of it, and there we find several difficulties, without taking into account imperfections in your apparatus. The first is the difference in the strength of the current used in the different systems, and, also, in many cases in different plants of the same system, the corresponding differences in the resistance of each lamp, and frequently, unequal adjustments of lamps in the same plant.

For convenience we are in the habit of referring to those systems in which a small current and a long arc is used as high tension systems, and those in which a large current and short arc is used as low tension systems. The requirements of the low tension seems to be a carbon that is hard, well plated, and a good conductor, the latter being the most important. In the high tension, on the contrary, hardness and conductivity seem to be of secondary importance. There is a tendency to flame and burn unsteadily when a hard carbon is used in these systems, and a softer one sometimes becomes necessary, which in many cases shortens the time in which a lamp will burn without being retrimmed, but, in such case the difference is fully made up in the brilliancy of the light. On the other hand, where a soft carbon is burned in a low tension current, the tendency is to form needle points which prevents the carbon from centering properly, causes them to heat, and is apt to burn the holder.

Let us pursue the inquiry touching the questions of size, con

ductivity, mortality and light, and ascertain if definite relations can be established in regard to them that may result in guiding us to the selection of perfect carbons for use from a mass of mechanically good carbons.

It is a matter of great interest to know in what manner and to what extent the size of the carbon affects the result in a current of given strength, covering, of course, in the general question of conductivity, the all-important results of light and life.

It is well known that a hard carbon offers less resistance to the current, or, in other words, has greater conductivity than a soft one; therefore, in carbons of the same length and diameter, made of the same material, by the same process, conductivity increases and diminishes respectively with their hardness and softness.

In either hard or soft carbons whatever of conductivity they possess respectively will be increased or diminished as their diameters are increased or diminished, the length being maintained. It would appear, therefore, that it is possible to make a softer carbon of larger diameter that will be the equivalent, in conductivity, of a harder carbon of smaller diameter.

Of carbons of the same *hardness* and length, but having different diameters, the larger will, undoubtedly, outlive the smaller. Of carbons of the same *diameter* and length, but differing in hardness, the harder will outlive the softer. Therefore, a carbon of larger diameter which is soft, may be equivalent to a smaller carbon which is hard, as to life, just as it has been shown to be equivalent in conductivity. The life of a carbon is, of course, dependent upon many vicissitudes, such as high winds, broken globes, etc.; but under the same conditions the statement made above is, undoubtedly, a fact.

It is well known and admitted that as between hard and soft carbons of the same diameter the latter will give a more brilliant light. It is just as well known that in case of hard carbons those of smaller diameter will, within certain limits, give a more brilliant light than those of a larger diameter. On the above statement of facts it may be regarded as settled then that with the same diameter, but differing in hardness, the hard carbon will possess greater conductivity and have a longer life, but with less brilliancy of light; while the softer carbon will have less conductivity and a shorter life, with a more brilliant light. And, further, that with uniform hardness, but differing in diameter, the larger diameter will have the greater conductivity and longer life, with a less brilliant light; while the smaller diameter will have less conductivity and a shorter life, with a more brilliant light.

The foregoing statements indicate invariably that with greater conductivity light diminishes and life increases; and, conversely, that with diminished conductivity the brilliancy of the light is increased and the life shortened. In corroboration of this it appears that a small, hard carbon is, practically, the equivalent of a larger, soft carbon, their conductivity being also equivalent.

Heretofore, it has been considered probable that the diameter, candle power, resistance per lamp, conductivity of the carbon point, and strength of current, are all interdependent, and a change in any of them will affect all the others, requiring a counteracting change or adjustment in some of them, in order to restore the proper relations between them. This, if so, you can readily see is difficult to do; for part of the work is to be done by the manufacturer, and the remainder is under your control. On the other hand, if the deduction can be properly made from the statements herein presented, that the resistance of the carbon point will determine its capability in respect to light and life in the different currents, the trouble is practically removed. It is not impossible, I think, to construct a machine that will, at no great increase of cost, assort the carbons into groups of uniform resistance or conductivity. Then, with constant currents, clean lamps, perfect connections, and insulation, you will ascertain practically that carbons mechanically good will prove to be good and uniformly so in actual service.

Much more could be written upon this interesting question, but this paper is already too long. I have noted for your discussion some important points which I hope your experience will enable you to determine definitely if they are well taken or not. I would be glad to have the whole question of the imperfect burning of carbon points thoroughly canvassed, so that manufacturers would get some hints as to what may be done by them in the way of correction when the fault lies at their door. It is especially desirable to be informed if that very disagreeable feature in the burning of carbons called "flaming" is always the effect of one particular cause and what that cause is.

LEATHER BELTING—ITS ORIGIN AND PROGRESS.

BY CHAS. A. SCHIEREN.

In the early part of this century the first attempts were made by English machinists to transmit power by means of bands or straps made of leather; this transference of power from one line shaft to another, needed a peculiar quality of material, one that combined pliability, solidity, and strength, and leather was the only known substance which suited that purpose. Many experiments have been made since then with other materials such as rubber textiles, wood, paper, and even iron and brass; also belts woven of horsehair, etc., but none have been able to supersede leather, and even to this day it is universally acknowledged that

"That there is nothing like leather
When well put together."

Belts made of leather are given the preference wherever they can be used, and it is somewhat strange that the machinery world of to-day know so little about the origin, progress and growth of an article that plays such an important part in the transmission of power, as leather belting.

For the benefit of those who have not read up the history of belting, I will give a brief account of the development of its manufacture in this country, and it will then be seen that this branch of trade has kept steady pace with this progressive age. Previous to 1820 and even up to 1835, much of our machinery, which then consisted principally of looms, etc., was imported from England and had all the necessary belting sent with it. These belts were made in a very crude way, generally from heavy leather and were cut across the hide, so that all the laps or joints were from the belly part of the hide. These parts were lapped over from six to eight inches and were not cemented, but were sewed together along the edges with white alum-tanned leather, similar to lacing; then large heavy rivets were put in the centre, and the whole thing made as clumsy and as heavy as possible.

In those days machinery was run at a very low rate of speed, the belts had to bear a severe strain, and therefore generally proved unsatisfactory; so much so, that machinists became discouraged and used gear wheels and upright shafts instead of belting. Upright shafting was largely used in flour and other mills where heavy work is required, as late as 1860.

Belt making up to 1840 was hardly known. Leather dealers and curriers, it is true, kept some extra dressed leather on hand for belting purposes, which mill owners and saddlers bought and made up into belting. All this stock was neither selected nor stretched, and the quality of belting it made can easily be imagined. In 1842, Wm. Kumble commenced the manufacture of leather belting at 33 Ferry street, New York. He also had a tannery in Frankfort street, where the bridge stores are now located. The foreman of this tannery, Mr. Fred. Wood, an ingenious and enterprising mechanic, invented some of the machinery necessary to stretch and join a belt in order to make it run smoothly, evenly, and straight. Mr. Kumble gained quite a reputation at this, his new enterprise, and it was not long before he had several competitors. Thus belt making became a distinctive and separate business, and before long, through Yankee push and ingenuity, we manufactured a belt in this country which was far superior in quality and workmanship to any made in Europe. Since this we have not lost our advantage, but on the contrary have made such great strides in this line of business, that to-day it is universally acknowledged that the United States turns out the best belting in the world, and American belting is as much sought after in England and France as the Peep O'Day Yankee Clocks are in England.

European belt makers are striving to imitate our methods of making belts, and for this purpose purchase our improved machinery, with which they hope to make a cheaper belt of equal quality, and thus drive out American competition.

However, I must return to my subject. My first illustration shows the method first employed for making a joint. This was, of course, found to be very deficient and soon an improvement was made which consisted in champfering the end of the under lap, which came in contact with the pulley, so that the belt was much smoother and better.

Waxed thread was used to sew the belt, and light rivets were used in the construction, which made it run easier, but as the leather was not stretched, the belts would stretch all out of shape and the pulleys had to be flanged in order to keep them on. Not until Mr. Wood conceived the idea of stretching leather before being cut into belting, was this trouble entirely obviated and a flange on the pulleys no longer needed.

The inventions of Mr. Wood, however, are now superseded by more valuable improvements which supply the present demand for perfect running belts, and the belts of to-day are as much superior to the belts of Mr. Wood's time, as is the steam engine of to-day, to the steam engine of 1840. When Mr. Goodyear invented belts made of vulcanized rubber, everybody thought that they would in time supplant leather. Rubber belting offered great advantages, being cheaper and made without joints, perfectly even and smooth, and apparently run much easier. However, many disadvantages were detected by actual use, and very soon rubber belts took their particular place in the use of belting, and are now manufactured in very large quantities; but for all swift running machinery leather is absolutely necessary and most reliable, and generally preferred.

During the war the demand for belting increased enormously, and it taxed the facilities of the belt makers to supply the demand. This made them somewhat careless and the quality of belting greatly deteriorated. The aim of the belt makers seemed to be, how much of the hide they could put into belting irrespective of quality. At this time, Mr. Underwood invented a method of making belts of pieces of leather six to seven feet long.

He put short laps at both ends and covered the thin and flabby neck leather with splits which made them even with the butt ends. These belts proved to be total failures, and were soon abandoned. Mr. Underwood, however, made many other valuable inventions; his well-known copper shank rivets and burs, placed on the ends of laps to prevent them from raising, are still used by some; and his patent angular belts created quite a sensation when first introduced. The latter was a novel and ingenious invention. Great power could be transmitted with narrow angular belts, but they have outlived their usefulness and are now supplanted by other later inventions.

In the midst of this great demand for cheap belting, Mr. Joseph B. Hoyt revolutionized the trade by going to the other extreme. He gave orders that all of his belts should be made with short laps only, that the butt end should be joined to the shoulder lap, to accomplish which the whole shoulder had to be cut away. He ordered also that only 36 inches of the centre of the hide should be used, and that every width of belt should be stretched by itself. This was a most radical change and startled the trade, while it gave Mr. Hoyt a world-wide reputation for belt making, which he held until his retirement from business with a large fortune, a few years ago.

Mr. J. B. Hoyt deserves credit for having established a *standard* for belting which is reliable and cannot be surpassed, unless indeed the nature of the steer hide changes. The trade everywhere has been compelled to adopt this method of making belts, because customers have been educated up to it, and many of them will buy nothing else.

About 1865 our manufacturing industries developed to an enormous extent, and immense factories were erected which required engines of great power, that could transmit from 500 to 1,000 h. p. This created a demand for very wide main driving belts, and great difficulty was experienced by belt manufacturers in making wide main driving belts over 36 inches which would be of uniform solidity and equal tension. Whole hides contain on an average 36 inches in width of solid leather, and never exceed 45 inches, while orders come in from all sides for main driving belts from 50 to 75 inches in width. Ever since this time experiments have been made on wide belting, and to-day we have reached such a state of perfection that leather belts of any desirable width can be constructed.

A main driving belt is now generally made on the following plan: Take for instance a double belt six feet wide. (See illustra-

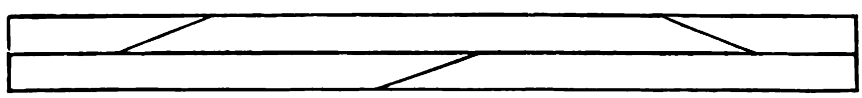

FIG. 1.—Diagram Showing Parallel Seam or Joints for Wide Belts.

tion.) The lower or running part of the belt consists of two pieces of leather of equal widths, cut from the centre of the hide and joined together parallel; then a 36 inch piece is placed in the centre of the lower two belts, and two end pieces filled out to the required width, and all joined with parallel joints. This makes a belt of uniformly solid leather and equal tension, and one which is bound to run perfectly smooth and straight. Powerful stretchers have also been invented which can take in any width of leather.

Alexander Bros. patented a method by which they can use side leather and accomplish the same result. However, they do not make a parallel joint, but simply butt the pieces together, as above shown, and then cement and rivet the same.

Eastern belt makers were the first to produce a light double belt with neither rivets nor other fastenings, claiming that rivets

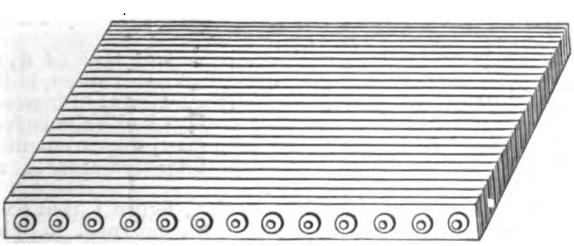

FIG. 2.—Edge Cut Leather Belting.

and burs were not necessary if a belt was properly cemented. They were used for machines running at a high rate of speed.

About 1864, L. N. Clark, of Boston, Mass., made that line of belting a specialty. He produced a belt which would probably find great favor to-day for running dynamos. His method was to split the pieces of leather to a perfectly even thickness and then cement them together. This made a double belt, rather thin, but well calculated for high speed. Mr. Clark retired from business about 10 years since.

Many experiments have been made to combine textile materials and leather in the manufacture of belting. In 1872, Messrs. Clark and Slemmer, of Philadelphia, patented a belt of this kind. Their method was to stretch a heavy piece of cotton duck of the width required, and place it between two thin pieces of leather of the same width. This made a strong belt which at first was received favorably by the trade, but which in the end, did not wear well because there were two different kinds of material used; the cotton would stretch more than the leather, or vice versa, and the belt would very soon work itself loose, and the cement and rivets break. Very few of these belts are in use at present. Another method is used which was patented by T. Thompson, of Cincinnati, and which is now manufactured by an eastern concern. In this process, as in the other, a heavy cotton duck is stretched, a thin layer of leather splits cemented over its surface, and then the two sewed together.

These belts are used to some extent on dynamos. Their main weakness, as already stated, is the unequal stretching qualities of

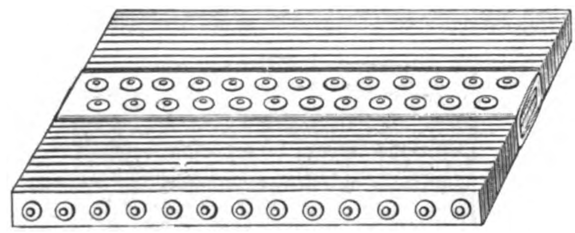

FIG. 3.—Edge Cut Belting (Howe's Patent).

Shows a device in the centre to make the Belt conform to the rounded face of the pulley.

the two materials used, but this objection is not so marked where thin pieces of split leather are used, as above described. The atmosphere, however, exerts a great influence over these belts, and they contract or expand with heat or cold, and cannot therefore be recommended except for easily adjustable machinery. Numerous other patents have been devised but are of minor importance.

Edge Cut Leather Belting.—These belts are hardly known here but are largely used in England for running machines where slow, heavy and positive motion are required, and they do excellent work.

These belts are made in the following manner: The leather is dressed and stretched the same as for ordinary belting; it is then cut into strips one inch wide and holes punched at distances of one inch from each other, to admit of steel bolts being inserted. These strips are then placed side by side until the desired width is obtained, when they are bolted and riveted together. This makes a belt which is rather clumsy, heavy and stiff, but one that can stand more strain and hard work than any other belt made, and is very powerful.

This audience, however, is probably interested more in the progress and improvement made in leather belting for special

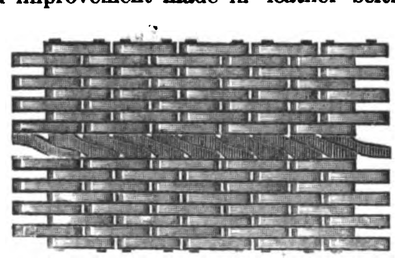

FIG. 4.—American Patent Joint.

use on dynamos and electric light machinery, than in the progress made in any other branch of the trade. I shall therefore describe different styles of leather belts which have met with great success in this field.

When the electric light first came into use, electricians found it exceedingly difficult to get a belt suitable to use on dynamos. All of the belts which they tried seemed to lack something, and ofttimes the heaviest and most carefully made leather belts failed to do the required work. This problem received special attention by some of our most enterprising belt makers, and various methods for making these belts were introduced with more or less success. About five years ago, the writer experimented on producing a belt which would be particularly fitted for transmitting power when run at a high rate of speed. I considered the stretching process of leather for dynamo belts the most important, because the steer hide by nature forms a peculiar shape, having fine and solid fibres on the back and then rounding off towards the belly with loose coarse fibres; to get therefore a perfectly flat piece of leather of even tension from the centre of the hide needs the utmost care.

The wide pieces of the centre are generally put into the stretching strain leaving the short piece free, and thereby stretching the whole piece on an equal strain; or, to explain it more fully, if you wish to stretch a 24 in. centre piece of leather, you place your clamps eight inches on each side and leave the centre eight inches clear; this will draw up enough under the strain of the side pieces to be perfectly even, or rather, the side pieces which contain more stretch, will draw its tension even with the centre.

I also prepared a dressing or extra coating for the leather which made it very pliable and also very smooth by filling its pores. Another important improvement for dynamo belts, was making them light double, and perfectly even in weight, so that every square inch of the whole belt was of even weight and tension throughout. This caused the belt to run without vibrating like ordinary belts; to run more steady and give a uniformity of power,

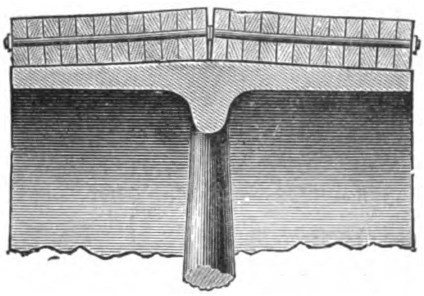

FIG. 5.—New Style with Two Bolts.

so necessary for producing electric light. Nor did the belt contain copper rivets and burs or other obstructions, but simply small wire endless screws; and its tensile strength was greatly increased by fastening the edges of the belt with these wire screws which held the leather firmly together, and yet offered no obstruction to the smooth surface of the belt.

However, no belt has ever created such a sensation in the trade as leather link belting.

This is a comparatively new article in this country, having been introduced two years ago. Since that time so many improvements have been made in this line of belting, that it can now be used on any kind of machinery. During the past two years these

FIG. 6.—Half Crossed Belt.

belts have done excellent work. They are made in the following manner: Small pieces of solid selected leather are dressed with tallow and neat's foot oil, which act as a lubricator to the joints of the pins. The leather is then put through rollers and made very solid; it is then cut into small links; this process makes a link of remarkable tenacity and strength, and one which will bear more strain than a piece of hard rolled *sole leather*. The links are then carefully assorted as to thickness and the belt built up to the required width. It is of great importance that each belt be made up of accurately assorted links, in order that an even width and perfect running belt may be secured.

A joint is of great improvement in this line of belting. Two bolts are used to each width of belt, and the two widths ingeniously joined together, forming an unbroken surface. This makes a belt which will conform itself to any pulley, whether flat, rounded, or cone.

They should be run as loosely as possible, and should not be taken up unless they actually slip. An inexperienced person upon seeing one of these link belts running on a dynamo would naturally think that the belt was loose and needed tightening, but these belts have such a remarkable grip power, that though when running the upper part of the belt is so loose that it almost describes a semi-circle, the under side is as tight as possible. Leather link belts will in time find great favor with belt makers, as they are more pliable than any flat double belt can possibly be made; and for belts running at right angles I claim that they are the only reliable belts for such a position that will give satisfaction.

ABSTRACTS AND EXTRACTS.

THE SLATTERY INDUCTION SYSTEM.[1]

FOR many years past a number of the brightest electricians of the world have been engaged in a close study of the laws governing the actions of alternating currents, and especially have directed their efforts towards solving the problems underlying the operations of induction coils or converters, used as one of the prime factors in a system of electrical distribution.

M. M. M. Slattery, one of the earliest practical workers in this latter direction on this side of the Atlantic, who has lately joined issues with the Fort Wayne Jenney Electric Light Co., has devoted much time during the past three years in working out and putting in practice a system of electric lighting in which inductoriums are used, and which, from all accounts, appears to leave little to be desired in the perfection of detail and in the success in general which has attended his practical efforts in this extensive field.

Mr. Slattery's first experiments were in the line of Gaulard & Gibbs' work, with a view to increasing the efficiency of the converter used in this system and reducing it to a commercial basis. At an early stage, however, when working in this direction, he became convinced that, owing to fundamental electrical difficulties which existed in this system, and which appeared to him impossible to eradicate—reference is had especially to the development of counter E. M. F. with the coils placed in series in the line —he turned his attention to the utilization, instead of the suppression of certain laws which govern the action of inductoriums. His next step was, instead of placing the inductoriums in series in the main line, as in the case of Gaulard & Gibbs' system, to dispose of them in multiple arc, and from that period up to the present time he has been, as stated, engaged in perfecting the multiple arc inductorium system. In working out this system, Mr. Slattery has been ably assisted by Robb MacKie, who is assistant electrician of the Fort Wayne Jenney Electric Light Co. The various factors comprising the system are shown in the accompanying drawings.

The principal features of the alternating systems of electric lighting are so well understood that it might be considered superfluous to give any detailed description thereof at this time. In a few words, however, it may be stated that the first plant put in practical operation by Mr. Slattery, in Woburn, Mass., had a primary main line pressure of 1,000 volts at the poles of the primary coil and 50 volts at the poles of the secondary coil of the converter. These converters were placed in multiple arc in the circuit, and are to-day working as perfectly as upon the first day they were set up—more than two years ago.

Dynamos.—In deciding upon the particular type of dynamos most suitable for the work to be done, two were chosen, built, and put into practical operation. These types were the Siemens' disc armature and the Lontin, and after careful and exhaustive test, the Lontin type was selected, and with many improvements, electrical and mechanical, is accomplishing remarkable results wherever it has been put to work.

It will be seen from the engraving, figure 1, that so far as symmetrical mechanical construction is concerned, in which is combined rigidity and simplicity throughout, the builders are warranted in the confidence they justly feel in the successful performance of the work that has to be accomplished by it.

When it is said that upon the armature of the machine capable of supplying 1,800 16 c. p. 50 volt lamps there are but 35 pounds of copper wire, it will be understood by those familiar with the business that the ideal construction is closely approached, and that the greatest care has been exercised in electrically disposing of every part of the dynamo, with a view of obtaining maximum efficiency from the minimum of mass. After careful experiment, it was further decided that it was more simple, more easy, and safer to operate a separately excited dynamo than a self-exciting dynamo. Both kinds were built, and the results which have fol-

1. From the *Western Electrician*, February 18, 1888.

lowed the adoption of the separate excitation would seem to indicate a judicious selection.

Figure 2 illustrates the type of exciter employed with this system, and, as will again be seen, simplicity of parts characterizes the mechanical skill which has been employed in its construction.

Converters.—**An exterior view of the converter is shown in figure 8. The interior construction is briefly described: The copper wire is wound upon a core consisting of insulated iron plates, rectangular in form, divided centrally, and placed back to back, previously having had a sufficient portion of the centre cut out, in which space the coil referred to is wound. The magnetic circuit is then closed around the sides of this coil by the other half of the rectangular plate referred to. The coefficient of induction in this converter is equal to a volt per five inches of wire, the ratio of**

danger whatever, to make and leave everything secure about the connections of the apparatus.

Instruments.—**The central station instruments, viz., pressure indicator and ammeter, are especially constructed for measurements of alternating currents and potentials, and are both simple in construction and extremely delicate in operation. A description of one instrument will answer for both. Two flat metallic spools divided at one side, have wound thereon the requisite number of convolutions of wire. These spools are mounted upon a rectangular frame common to both, one being placed in eccentric relation to the other, in order to modify the parallel plane of the convolutions of the respective coils, for the purpose of reducing self-induction. In order to obtain a due and proportional measurement of current or potential in relation to the spools a circum-**

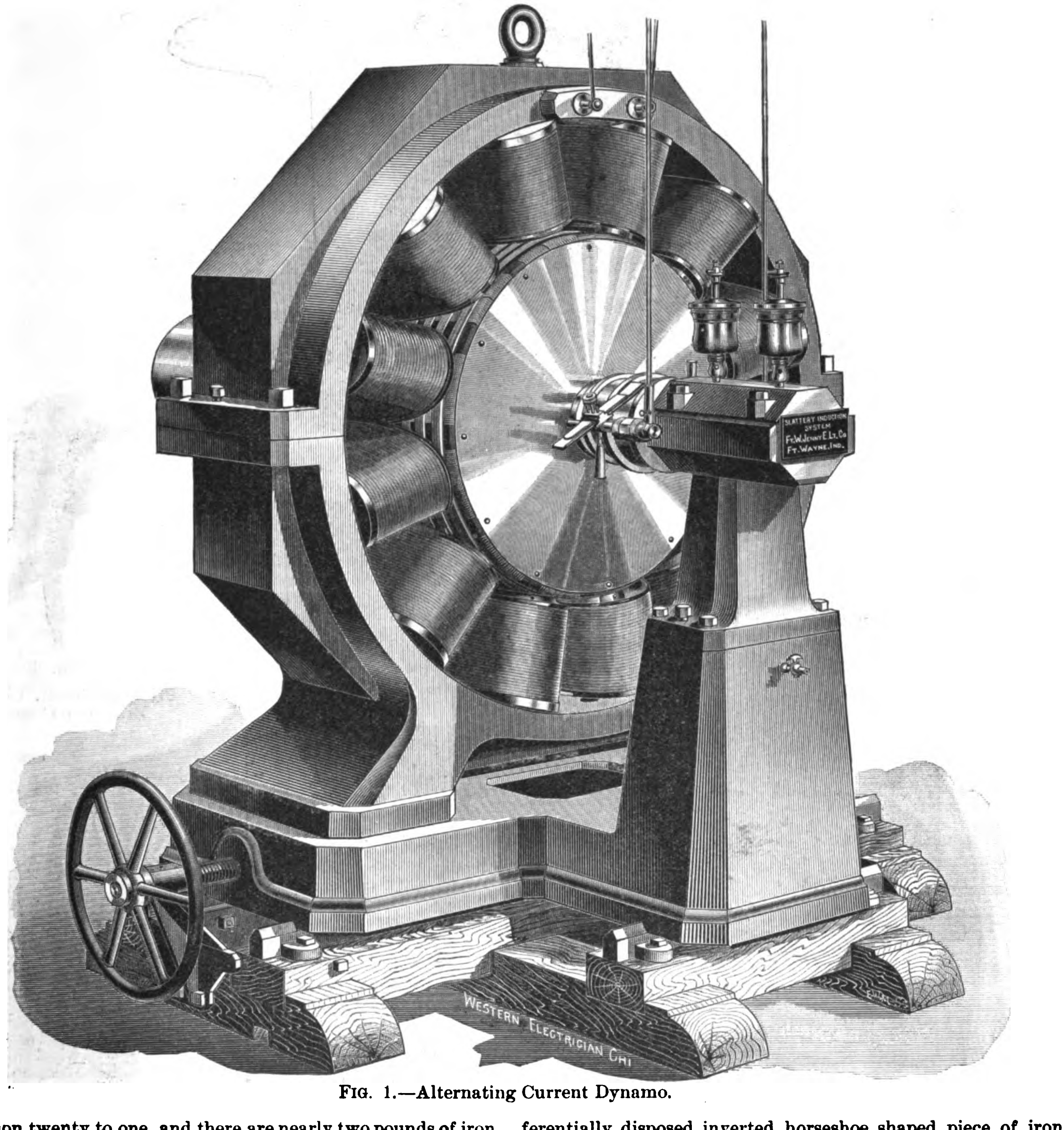

FIG. 1.—Alternating Current Dynamo.

conversion twenty to one, and there are nearly two pounds of iron per secondary ampere capacity. The working pressure of the system is 1,000 volts at the poles of the primary coil and 50 volts at the poles of the secondary coil.

A special insulating compound is used in these converters, and this is of such a character, that the chance of cross circuiting of the convolutions of the primary coils are very remote indeed. In each converter, conveniently placed, are primary and secondary fuses, which are easy of access, and exceedingly safe in event of a necessity arising for the renewal of a fuse upon the line circuit; a simple device in connection with the primary fuse enables the attendant to cut the converter entirely out of circuit during the introduction of a new fuse, thereby enabling him, without any

ferentially disposed inverted horseshoe shaped piece of iron is attached to a central shaft, which is mounted upon jeweled centres, and carries a pointer, which is deflected according to the varying potentials and strength of current.

The instruments are placed in a case having a glass front, and are disposed in a conspicuous position in the central station, so that the attendants may see at any moment what is taking place in the external circuit.

Meter.—Not the least of the important factors in this system is a meter for measuring the energy supplied to each customer, the extreme delicacy and accuracy of the working of which, can not be too highly estimated.

Multiple arc coupling device.—A very simple central station

device is used for safely and easily coupling alternating current dynamos in multiple arc. To accomplish this object there have hitherto been used electro-magnetic devices, synchronizers, etc.,

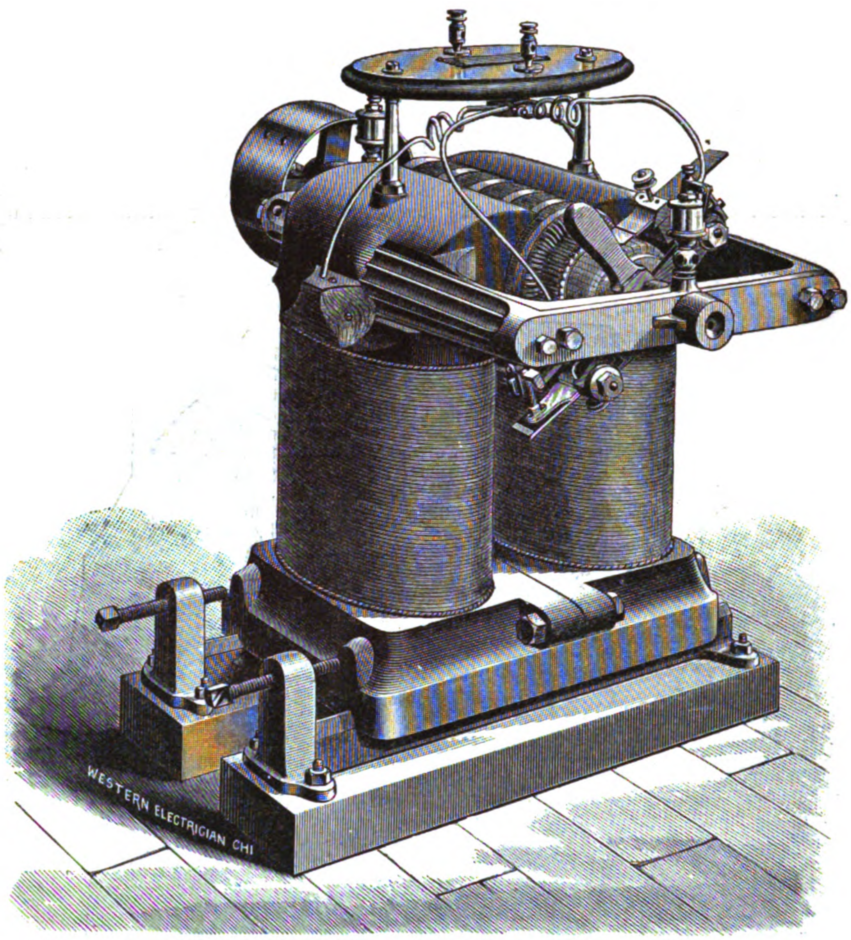

FIG. 2.—Exciter.

but as these devices require very rapid action and necessitate exceedingly great care in operation, they can not always be de-

FIG. 3.—Resistance Box for Exciter.

pended upon to perform successfully the work required of them. In the case of the apparatus that Mr. Slattery uses for this pur-

FIG. 4.—Primary Circuit. Branch Clamp.

pose, the coupling of dynamos in multiple arc is reduced to a basis of such simplicity that an ordinary central station assistant will have no difficulty in coupling and running the dynamos together.

Recorder.—Another useful central station apparatus, devised

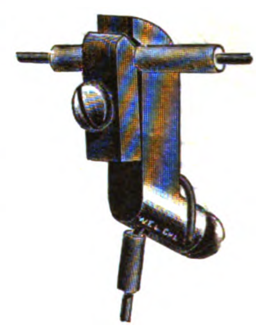

FIG. 6.

Primary Circuit. Clamp for Branch to Converter.

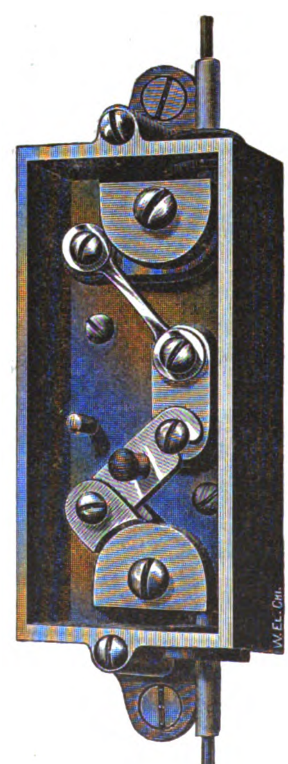

FIG. 5.

Primary Circuit. Branch Fuse Box (cover removed).

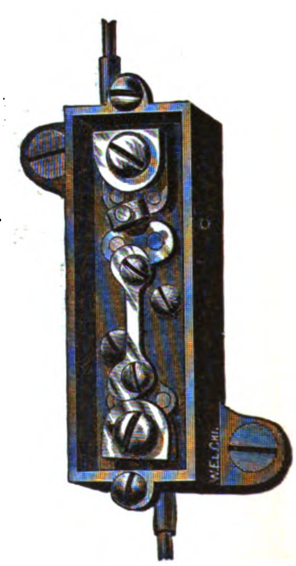

FIG. 7.

Primary Circuit. Fuse Box for Branch to Converter (cover removed).

by Mr. Slattery, is chiefly to be used by central station superintendents. This device is placed by the superintendent in proper

relation in the circuit for the work it has to do—at night, for instance, as he leaves the station. In the morning when he returns he consults the apparatus, and sees exactly the extent of the irregularity due to the carelessness of the attendant, and the electrical disturbance which may have taken place during his absence. This will, no doubt, commend itself to central station superintendents as a means of compelling, if possible, more care-

FIG. 8.—Converter.

ful performance of duty, a laxity of which has frequently resulted in many irregularities unpleasant to relate.

Arc lamps.—This system would not be complete without an arc lamp and motor. Mr. Slattery makes a special converter for operating arc lamps in multiple arc, which, although it has not yet been placed on the market, has been for some time working successfully at the factory, and preparations are now being made to manufacture these lamps and introduce them for public use.

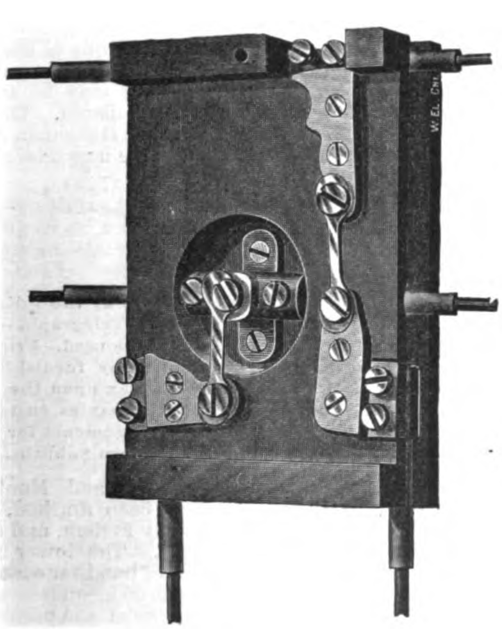

FIG. 9.—Secondary Circuit. Entering Fuse Box (cover removed).

An excellent feature about this apparatus is that arc lamps of various illuminating capacities can all be used in one general system, these capacities varying between 300 and 2,000 c. p. The converter constructed to work in connection with this lamp is only a trifle larger than an ordinary exterior arc lamp cut out, and in consequence of such desirable compactness, may be disposed of with as much ease.

Motor.—The motor referred to is still in an experimental

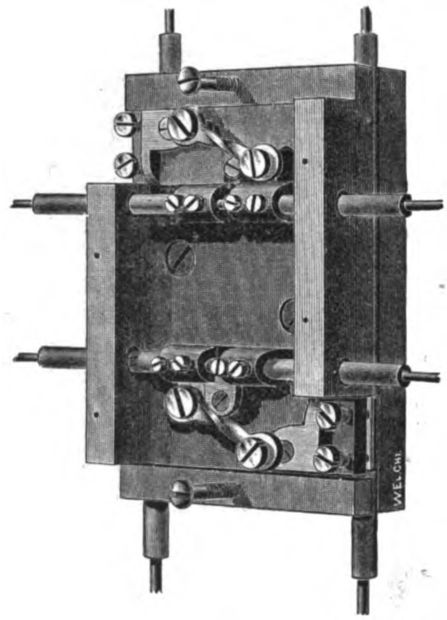

FIG. 10.—Secondary Circuit. Double Pole Fuse for Cleat Wiring (cover removed).

stage, but in an advanced one, and considering the activity and ingenuity displayed by Mr. Slattery, and his able assistant, Mr. MacKie in working out this system, it may be fairly anticipated

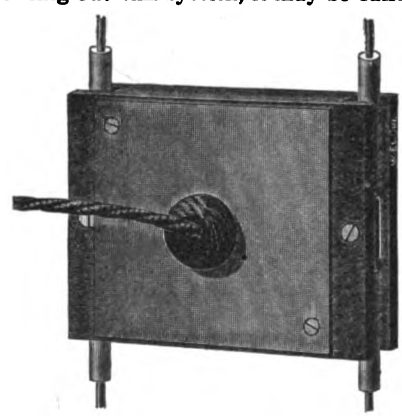

FIG. 11.—Secondary Circuit. Single Light Fuse for Cleat Wiring.

that before long the success which has characterized their efforts in other directions, will be fully realized in this.

Wiring fixtures.—Figure 4 is an adjustable clamp branch connector, used to connect branches with the main line and enables

FIG. 12.—Wall Switch. FIG. 13.—Wall Socket.

Secondary Circuit.

the lineman to dispense with the use of solder, rendering the work more expeditious, and making a far more effectual joint. In conjunction with this branch connector, is used a branch switch safety fuse, figure 5, which is placed at the junction of a primary branch and the main line. Here again the safety of

those whose duty it is to replace burnt-out fuses is considered, as they can by means of the switch, shown in the interior of the

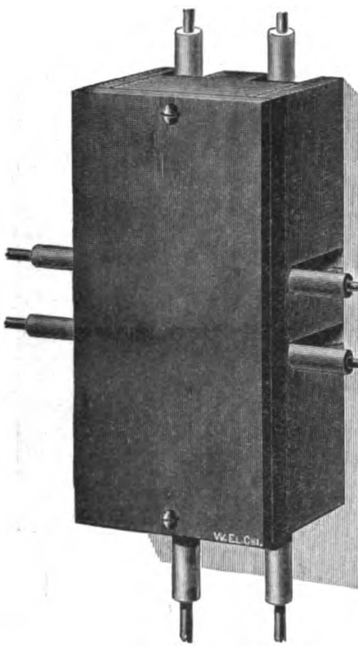

FIG. 14.—Secondary Circuit. Double Pole Fuse for Molding Wiring.

fuse box, disconnect the fuse terminal from the line and then

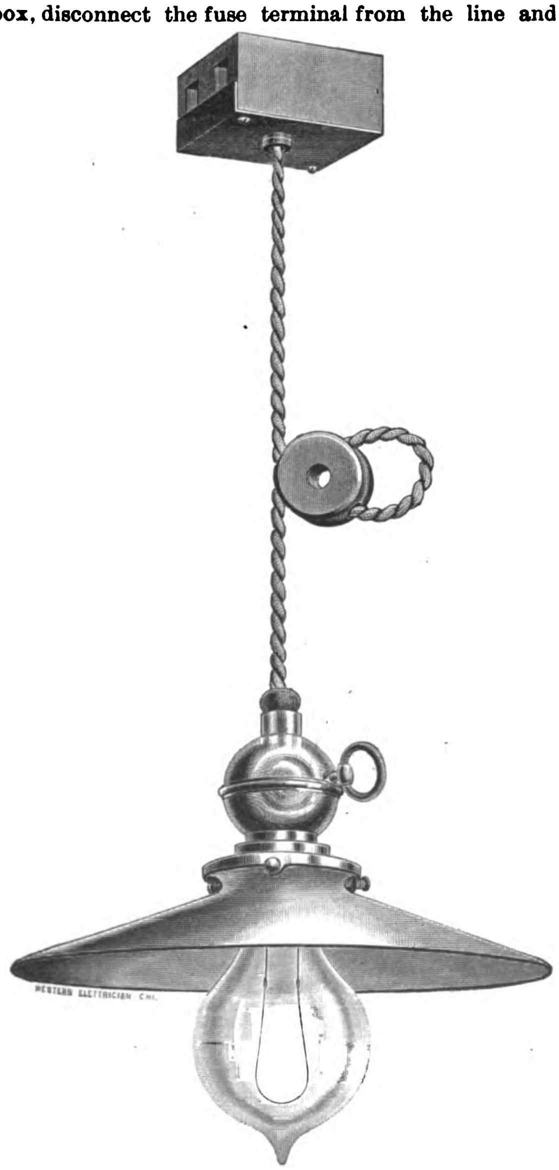

FIG. 15.—Single Light Fuse and Lamp Fixture, complete.

safely adjust the fuse. One of these boxes is placed on each side of a parallel circuit. Figures 6 and 7 are smaller sizes of figures 4 and 5, and are employed to connect the primary coil of converter with the external primary circuit. This method of introducing so many fusible devices throughout the system might be considered by some as superfluous, but if there is an error in question at all it will be considered as being on the side of safety.

Figures 9 to 15 represent the fusible wiring details, the special object in the construction of which has been greater facility in wiring and safety when wired, and evidences thorough familiarity with both plain cleat and molding wiring, and every requirement which may arise in this branch of work.

Figure 15 represents the lamp, shade-holder and key-socket. The lamps have a working life of some 800 hours, and twelve 16 c. p. 50 volt lamps may be operated with the expenditure of one horse-power of energy—results that are decidedly creditable.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Explosion of Illuminating Gas in a Conduit.—The Telephone Service.—The Copper Market.—Electric Traction on Fourth Avenue

THE dangers arising from the accumulation of illuminating gas in subway man-holes are being rapidly confirmed as these structures become more plentiful. It was but five weeks ago that Leonard Jones lost his life in this city from the above cause, and on February 24, a series of explosions occurred in the unfinished subway of the Bell Telephone Co. at Buffalo, by which Fred Zott, and William Wood, employés of the Western Electric Co., were terribly burned, and another man stunned. Five man-hole covers were thrown in the air, but the damage does not appear to have been as serious as in similar explosions at Philadelphia.

General manager Eckert, of the Metropolitan Telephone and Telegraph Co., gives the New York subscribers credit for being fairly expert in the use of the telephone. Owing to the vast number of wires of all kinds used in this city, the telephone service is not what it should be, but with the early adoption of metallic circuits a great improvement is expected.

The proceedings of the copper trust are of vital interest to the various electrical industries, and a hope has existed that the advance in prices was but temporary. The information which is now public regarding the manipulation of the world's supply indicates that there is little hope for lower prices as the syndicate has contracted for the output of all important mines for three years in advance. Nothing but a decided decrease in the demand is likely to thwart the plans which have been very carefully made. While copper has been introduced for line construction by telegraph and telephone companies to a limited extent, its superiority for their use is not sufficiently marked to prevent their return to iron.

The indications for the general adoption of electric traction on the Fourth avenue railroad in this city are very favorable. The car fitted up by the Julien Electric Traction Co. is now making regular trips, and is being skilfully handled by one of the regular horse drivers assigned to that duty. Eighteen more cars are to be fitted up with such improvements in detail as may be suggested by the experience which is being daily accumulated. The horses do not take kindly to the innovation, and the stablemen and hay dealers do not look with entire favor upon the new motor car, but "it gets there all the same."

NEW YORK, Feb. 27, 1888.

PHILADELPHIA.

The Lighting of the New Grand Opera House by the Edison Co.—Mr. Powderly's Efforts to Secure a Postal Telegraph.—Another Electric Railway.—The Wharton Motor to be used.—Front Street Store-keepers think they can Economize by furnishing their own Electric Light.—The Pole and Wire Tax upon the Western Union and Mutual Union Telegraph Companies sustained by the State Supreme Court.—Temporary arrangements for the City Lighting.—Rapid Transit to the Northwestern Suburbs.

THE new Grand Opera House, at Broad and Montgomery avenue, in this city, which has recently been finished, is completely lighted by the Edison electric light system, and contains about one thousand incandescent lights. The lower foyer is separated from the auditorium by screens of handsome lead lights, studded with glass jewels and lighted with 36 incandescent lamps in various colored globes. Around the edge of the parquet there are 17 three-light burners, and in the gallery are 17 five-light chandeliers. In the foyer of the upper gallery there are 18 chandeliers of two lamps each, 120 lamps are in the ceiling, on the stage are five border lights of 50 burners each; there are also 50 bunch lights, and besides all these are electric lights in all the twelve large dressing rooms and in the green room. This immense system of lighting is completely controlled by nine levers on the stage, each lever controlling a certain section of the lamps, so that any section can be turned off without interfering with

any other. The foot-lights are of 50 burners. When lighted the opera house presents a very beautiful appearance.

General Master-Workman Powderly's recommendation that persons interested in the establishment of a government telegraph system, should petition Congress to pass an act to provide for such an institution, is being readily responded to from all sections of the United States. These petitions are forwarded to general headquarters of the order, at No. 814 North Broad street, and a room devoted to their reception is literally flooded with letters.

These petitions, which are addressed to Congress, state that the signers are citizens of a certain Congressional district, and that they pray for the framing and adoption of a statute providing for a government postal telegraph, with the reasons attached. Some of these petitions are of wonderful size. The Third district of California has forwarded a petition containing over 2,600 names. One from the Fifth, Kansas, has over 1,300 subscribers; the State of Colorado forwards one with 1,800 signers, and the Third, Massachusetts, has sent a petition signed by over 1,200 voters.

General secretary Litchman, in discussing the object of the movement, said: "We are much pleased that the signers of these petitions are not confined to the order, but represent the business element of the communities from which they come."

When the Lehigh avenue railway is put in operation, electricity will be the motive power employed. The company has completed its tracks from Fairmount Park to Second street, with the exception of about a quarter of a mile of double track in the vicinity of its intersection with the connecting railroad near Seventeenth street. It is the intention to avoid all grade crossings, and the line will not be finished at this point until it is determined to place the grade over or under the present railroad crossing. The Wharton motor, which has been tried with such signal success on the Chestnut and Walnut streets line, is being perfected for service on the Lehigh avenue road. The motor company has built 1,000 feet of track at its works, and tests are being carried on there. After the recent heavy snow storm the motor not only made its way against the accumulation of snow, but effectually cleared the rails.

The storekeepers on the west side of Front street, between Susquehanna avenue and Dauphin, the majority of whom have their stores illuminated with the electric light, have been discussing, for some time, the advisability of manufacturing electricity for their own use. They claim that the price charged for one electric light (60 cents per night) is entirely too much, and have figured it out that they can manufacture it themselves at one-third the price charged now. Accordingly a meeting has been held to perfect an organization. It is proposed that each storekeeper be assessed $150 to purchase a building and the necessary plant.

The Supreme Court has affirmed the judgment of Common Pleas Court, No. 2, in the suits of the city against the Western Union and Mutual Union Telegraph companies to recover the annual license fee of $1 for each one of their poles erected upon the public streets, and $2.50 for every mile of suspended wire. These license fees were imposed by an ordinance of January 6, 1881, but have never been collected. In affirming the judgment that court simply holds that the city, in the exercise of its police powers, has an undoubted right to impose a license fee on poles and wires, and that there is nothing unreasonable about the amount fixed for the fee.

Last month director Wagner postponed awarding contracts to electric light companies for furnishing lights on the different highways, owing to the Keystone Electric Light Company agreeing to furnish the lights at a considerably less amount per light, providing they were granted certain concessions by councils. He subsequently entered into an agreement with the various companies to furnish the lights during the first three months of the year, so as to give him an opportunity to communicate with councils and effect some arrangement by which the city would be benefited. At a meeting of the electrical committee, the director's communication asking for an appropriation to pay for this service was considered. A representative of the Keystone company was present, and stated, in answer to an inquiry, that his company was prepared to furnish lights of 2,000 c. p.

"How about the city of Philadelphia being compelled to pay more for electric lighting than is charged for similar service elsewhere?" asked one of the members.

"There are several reasons for this," said Mr. Graham. "The first thing is the number of hours each night the light is furnished, and the character of the light."

"If a contract is made for 2,000 c. p. light, why, we would have 2,000 c. p.," said director Wagner.

"Do you think that you can do better by waiting until April 1st, in awarding your contracts?" asked Mr. Graham.

"No, I don't. I can for the current year."

"It's pretty near time we had some good light at nights," said Mr. Van Dusen; "the gas is getting worse and worse."

After some further discussion the matter was referred to a sub-committee to examine into the whole subject, and report at the next meeting of the general committee.

The Rapid Transit Electric Railroad Company, which was incorporated at Harrisburg a few days ago, intends to introduce in this city a system of electric railways for the transportation of the public from the centre of the city to the extreme northwestern portion. In addition to the ordinary cars, seating twenty persons, this line will run during the morning and evening hours double-length cars, with seating capacity for fifty, thereby meeting the extra travel at those periods of the day.

PHILADELPHIA, February 16, 1888.

BOSTON.

The United States Supreme Court Inconsiderately Disappoints Speculators in Telephone Stocks.—Erie Telephone Co.'s Report.—Long-Distance Telephoning.—Death of Edward Farrar.—The Wilson Police Signals.—Extra Provision of Fire-Alarm Boxes.—The Mexican Telephone Patent Decision.—Fires from Electric Wires.—Underground Wire Franchises Sought.—Storm Signals Likely to be Suspended at Several Stations Through Want of Funds.

NOTWITHSTANDING all the cock-sure information given out by stock brokers who have private wires, and well-informed newspapers who have "inside information," the great decision on the appealed telephone cases has not at the present writing been rendered. Unfortunates, who relied on the private advices, and who carried Bell stock on margins have become tired out, as also have those would-be bears who have sold the same stock short. It is amazing that the Supreme Court has not attended to all this buzzing, fomenting and ebullition of the speculative parties who have been so anxious for a decision; they are worse than the railroad magnate who was said to have remarked, that the public might be short on future bliss, or words to that effect.

However, the Bell company do not seem to be embarrassed in consequence of the delay, it is understood that they used to sit up nights, in the early days of decisions, and walk the floor, but now they permit the other fellows to do that. In the Philadelphia case before Judge McKennon, there was a stay, because the judge wished the Drawbaugh case to be decided first by Judge Wallace, before whom it was pending, before *he* decided the case at his bar; when the news of the stay arrived at the Bell office, one of the shorthand young men, who was operating his type writer said, "Shall I stop where I am?" supposing the bottom had dropped out; as indeed many of the employers who were dabbling in the stock did, when the stock tumbled about 50 points and left them hung up. However, that did not stop them from doing the same thing afterwards, when their courage had returned.

The Erie Telephone and Telegraph Company makes the following very satisfactory report of operations for the third quarter and first nine months of its current fiscal year:

QUARTER ENDED DEC. 31.

	1887.	1886.	Increase.
Gross earnings	$160,071	$137,409	$22,662
Gross expenses	103,774	93,296	10,478
Net earnings	$56,297	$44,113	$12,184
Construction	14,408	8,820	5,588
Balance	$41,889	$35,293	$6,596
Dividends	36,000	24,000	22,000
Surplus	$5,889	$11,293	*$5,404

APRIL 1 TO OCT. 31.

	1887.	1886.	Increase.
Gross earnings	$460,281	$401,794	$58,487
Gross expenses	302,456	268,332	34,124
Net earnings	$157,825	$133,462	$24,363
Construction	35,414	23,077	12,337
Surplus	$122,411	$110,385	$12,026

SUBSCRIBERS ADDED.

	1887.	1886.	Increase.
Quarter, Dec. 31	89	238	*149
April 1 to Dec. 31	666	592	74
	1888.	1887.	Increase.
Connected Jan. 1	10,388	9,516	872

* Decrease.

The members of the Boston Electric Club, on the 31st ult., visited the rooms of the American Telephone and Telegraph Company, No. 53 Devonshire street, and tested the new telephone lines to Philadelphia, Albany and New York. In the last-named city, the New York Electric Club was engaged in opening its new club house at No. 17 East Twenty-second street, and a connection having been made, the members of the two organizations chatted pleasantly for more than two hours. The test was satisfactory.

Long-distance telephoning is now an accomplished fact for Boston. Several of our enterprising brokers and business men have leased private wires. The next thing is to build a line from New York to Chicago.

The following is from the Boston *Advertiser* :

Hon. Edward Farrar died at Keene, N. H., the 11th inst., of pneumonia, aged 66 years. He was the second mayor of Keene. He held the office of clerk of the courts for 30 years. He was the judge of the police court for 15 years, and he was a charter member of Hugh de Payens Commandery. He actually invented the first rude telephone in this country, although owing to his extreme modesty he never pushed his claim. In religion he was a liberal Unitarian. He leaves a widow and two daughters.

The Wilson police signal system is now almost ready for use by Police Division 5, South End, and it will probably be set in operation some time this week. Then superintendent of police, Small will at once begin the work of placing the necessary boxes and wires in position in Police Divisions 9 (Roxbury) and 15 (Charlestown).

Fire-alarm boxes have recently been placed on many schoolhouses in the city, and it is believed that no other city is so well protected in this respect. Special boxes have been established in many of the schools and hotels.

A City of Mexico despatch says that the favorable decision in the case of the Mexican Telephone Company is a decided victory for the Bell and Blake patents over German imitations, which are exact copies in the minutest detail of the American invention. The decision given by the First District Court will be appealed from, and recourse had to the Supreme Court. Under this decision, all instruments imitating American instruments must be given over to the Mexican Telephone Company, and every dollar of profit accounted for and turned over. The Bell and Blake patents were originally taken out in Mexico by Arthur P. Cushing, now Mexican consul at Boston, acting as agent for the American patentee.

In consequence of the above, the Mexican telephone stock has been quite active, better prices being obtained. A dividend is greatly longed for by the weary stockholders.

Ten fires were set simultaneously in this city on the morning of the 26th ult., by an electric light wire coming in contact with telephone and fire signal wires, says the *Herald*. Seven telephone boxes were burned out, and the fire alarms in the office of the Boston Board of Fire Underwriters, L. Burge, Hayes & Co., Mason Building, Kilby street, and at the central station of the Watkins fire-alarm signal. Fortunately, in every instance, the incipient blazes were discovered before they had done any damage.

An interesting record is kept by the New England Telephone Company of the number of telephones, call bells, etc., burned out by electric light and power wires, showing the efficiency of the protectors in use.

The aldermanic committee on electric wires met again on the afternoon of the 26th ult., for the purpose of further considering the petition of Messrs. R. M. Pulsifer, and others, that they may be granted a 20 years' franchise for the occupancy of certain specified streets in the laying of conduits for electric wires. Mr. Seth L. Powers, counsel for the petitioners, presented an amended petition. It provides that the franchise be given to the petitioners, their heirs and assigns, so that there might some day be a corporation formed; that only the best improved system shall be used, occupying not more than four square feet of space in a street roadway, although less may be necessary; to use only such locations as are determined by the superintendent of streets, and to pay $4 a day to such inspector as the superintendent may appoint while the work is going on; to restore streets to former condition and keep them in order for six months without expense to the city; to give a satisfactory indemnity bond of $20,000 before opening a street; to accommodate all the present and future city wires for 20 years free of charge. This petition differs from others which have been opposed in the courts in that it is for a definite period and for a consideration. But, even if the courts should decide adversely, the petitioners would lose their rights, while the city will lose nothing.

In answer to questions, Mr. Powers said the cost of maintenance of overhead wires was from $7 to $12 per mile; of conduits, much less, and better service was rendered. There are six systems of conduits in use, and we propose to adopt the best when we know what it is. In 1881 a permit was granted to have conduits laid, but nothing has since been done; therefore, this is the first organized effort of Boston capitalists to enter the business. A further hearing was given on the petition of Henry E. Cobb, and others, for the exclusive right for twenty years to build conduits in certain streets for telegraph, telephone and electric light wires. The petitioners agreed to give a bond for every street opened; to put and keep the streets opened in repair for a term of six months; to use only such locations as are determined by the superintendent of streets, and to use the best system of conduits.

Objections to granting an exclusive franchise were made by Messrs. Spaulding and Olmstead, representing a solid conduit system, and by Messrs. Burnham and Fitzgerald, representing the Franklin electric light system.

After a statement by Mr. Powers, that the petitioners would be glad if the board of aldermen could investigate all the plans and recommend the best one to the petitioners, thereby taking a great deal of work off their hands, the hearing was declared closed.

The committee on electric wires of the city government, gave a hearing on the afternoon of the 2d inst., to the remonstrants against granting the petition of R. M. Pulsifer, and others, for leave to lay conduits for electric wires in certain streets of the city. President Sherwin, of the New England Telephone Company, objected, because the petition was not sufficiently definite. Further remarks were made by Professor Cross, of the Institute of Technology, and Mr. Frederick Cartwright, of New York, and the case was then closed.

The remonstrants against overhead wires, having had the satisfaction of seeing the same placed underground to a large extent in the business streets, are now grumbling because their horses are frightened at the bonfires built over the man-holes of the conduits—to melt the ice and frost therefrom, in order that the interiors thereof may be accessible.

The sea captains and sailors hereabouts are much alarmed at the order from the War Department, at Washington, to the officers in charge of the signal service stations of the Atlantic seaboard, announcing that, the appropriation having run short, there is no money with which to pay the signal men of the several stations, and that those stations will have to be discontinued from January 20 to July 1. Captain Hayden, of pilot boat No. 3, Captain Fowler, the oldest pilot in the local service, the officers of the T Wharf Towboat Company, and others, are reported as saying that the storm signals are greatly needed at this time of the year on this coast, and if they are discontinued incalculable harm to life and property will result. The cautionary storm signals are eagerly watched for by sailors, who, when a storm is predicted, always remain in the harbor.

Sergeant J. W. Smith, who has charge of the signal service at Boston—the Boston "district" including ten minor stations—says that the display of signals will be discontinued at Chatham, Highland Light, Hull, Hyannis, Portsmouth (N.H.), and Provincetown, until Congress provides the means for their renewal. They will be continued at Marblehead, Gloucester, New Bedford and Newburyport—the more important stations in the district.

Sergeant Smith has notified the men at the posts at which the signals are officially discontinued, that the government will telegraph the bulletins if the men will display them (or the signals), without cost to the government. The men are usually telegraph operators, railway employés, or postmasters, and are paid for each time the signal is displayed—when the government has any money.

BOSTON, Mass., Feb. 16, 1888.

CHICAGO.

The Cushman and the Interstate Telephone Companies Seeking Franchises.—The Sun Electric Light Co. and the Chicago Arc-Light and Power Co.—The Death of Genl. J. L. Thompson.—The Semi-Annual Convention of the Edison Electric Light Association.—Mr. D. H. Louderback appointed General Manager of the Chicago Edison Company.—Mr. E. T. Baker Accepts a Position with the Western Electric Co.—Starting of the Thomson-Houston Plant in the Union Depot.—The Competition for the Topeka Arc Light Plant.—Statistics of Work in Telephone Exchanges.—A Clever Device for Registering Telephone Connections.—Rumored Removal of the Van Depoele Factory to Connecticut.—The Chicago Electric Club.—Western State Legislatures Anxiously Watched by Telephone Companies.—Decadence of Interest in Natural Gas.

THE American Cushman Telephone Co. has applied to the city council for a franchise to build and operate a telephone exchange in Chicago. It offers to guarantee the city and all users of the Cushman telephone against loss on account of suits for infringements of patents, and agrees to furnish telephones for eighty dollars per year. The Interstate Telephone Co. has also applied for a franchise and offers similar guarantees, with an agreement to furnish telephone service at no more than $60 per annum. The council committee to which the matter was referred, reported in favor of granting franchises to both the Interstate and the Cushman companies. The security with which the Cushman company carries on business is a good deal of a puzzle in view of the promptness with which other infringers are met with injunctions. It can hardly be, telephone men think, that the American Bell Telephone Co. fear to have Dr. Cushman's claims investigated. In many respects these claims are the most improbable which have been put forward in opposition to Bell. Whatever may be the reason why this company proceeds with its business comparatively without molestation, it seems to thrive. It is selling private line instruments and putting in exchanges in Indiana. At South Bend, there is a Cushman telephone exchange of seventy-five subscribers.

The Sun Electric Light Co. is operating about 300 arc lights and is the only considerable opponent the Chicago Arc Light and Power Co. has now in Chicago. As the Chicago Arc Light and Power Co. owns the Chicago Sectional Underground Conduit Co., which latter company is in possession of the only general underground franchise in Chicago, the Sun company is in a measure at the mercy of its powerful rival. It has accordingly appealed to the city council for an independent franchise to lay its wires

underground in consideration of which it agrees to light the streets in its territory, or wherever its lines run, at bare cost, the cost to be estimated by the city comptroller, and to pay to the city 2½ per cent. of its gross earnings. The council committee to which this application was referred reported in favor of accepting it and granting the franchise asked for.

The large central station of the Chicago Arc Light and Power Co. is now in successful operation. There are in use two large compound condensing engines built after plans prepared by Mr. E. F. Williams, of the Williams Engine Co. The transmission of the power to the lines of shafting is accomplished by ropes. From the shafting to dynamos the ordinary leather belt is used. The station has many novel features and is an object of considerable interest to visitors to the city who are interested in electric lighting.

The death of General J. L. Thompson, on January 31st, caused profound sadness among a wide circle of his friends and associates in electrical enterprises. At his funeral services which were attended by the most prominent members of the bar and bench in Chicago, and other well-known men who were General Thompson's personal friends, there were present representatives of the Western Electric Co., the Chicago Telephone Co., the Chicago Arc Light and Power Co., the Chicago Edison Co., the Central Union Telephone Co. and the Western Union Telegraph Co., in nearly all of which companies the general was a director at the time of his sudden death.

The eighth semi-annual convention of local Edison electric light companies met at the Grand Pacific Hotel, the 8th, 9th and 10th of this month. About 50 companies were represented. Mr. Edison himself was present and the meetings were said to have been very interesting. Mr. D. H. Louderback has been appointed general manager of the Chicago Edison Co., and assumed the duties of his position on February 15th

Mr. E. T. Baker, whom telephone men will remember as connected with telephone companies at Evansville, Ind., and Nashville, Tenn., has accepted a position with the Western Electric Co.

The Thomson-Houston electric light plant in the Union depot, which consists of 60 arc lights and 800 incandescents, was successfully started the last of January and has been in continuous and satisfactory operation ever since. This is the third of the five principal depots of Chicago which is lighted by electric lights. The Dearborn station has the Western Electric system, the Lake Shore has the Jenney.

There was the usual spirited contest between electric lighting companies over the contract recently let by the city of Topeka, Kans., for a 120 arc light plant. The bids put in by the various companies ranged from $26,950 by the Thomson-Houston Co., to $23,210 by the Western Electric Co. And the guaranteed cost per annum of operating the plant from $10,800 by the Brush company to $4,300 by the Western Electric Co. The Jenney Electric Co., of Indianapolis, were declared by the city council to be the "lowest responsible bidders," and received the contract.

Some of the telephone exchanges in the larger cities in the west have been keeping records of the work done by each operator. Mr. Durant, of St. Louis, has the highest record for a short space of time. In five minutes one operator made 53 connections and disconnections. The daily total and average per operator at St. Louis, however, is surpassed by the exchanges at Omaha, Kansas City, Nashville and New Orleans. The highest record for an hour comes from Nashville, where one operator made 248 connections and disconnections in one hour.

Mr. W. W. Smith, of Kansas City, has devised an ingenious arrangement for keeping record, automatically, of the number of connections each operator makes. A tinsel sleeve on each cord closes circuit each time it passes through the weight pulley and moves forward a hand on a dial one point.

It is stated that a syndicate has purchased the plant and patents of the Van Depoele Electric Manufacturing Co., of this city, and that the Van Depoele factory will be removed to Birmingham, Conn.

The Chicago electric club rooms were made the headquarters of the delegates of the electric light convention who went on to Pittsburgh on the afternoon of Monday the 20th in a special car. The rooms of the club have been more than usually lively and interesting of late, owing to the acquisition of handsome billiard tables, which are very well patronized. Only one meeting of the club was held this month owing to the absence of so many of the members at Pittsburgh, on the regular date of the second meeting. Dr. Whitefield read a very interesting paper on the uses of electricity in dentistry.

The legislatures of Kentucky, Ohio, Iowa, Utah and Wyoming, are the only ones in session in the west. Their proceedings are anxiously watched by telephone men, but the impression is that pending the decision of the telephone case by the United States Supreme Court there is little likelihood of any such action on the part of the legislatures as has led to such unfortunate results, both to the telephone company and to the community in Indiana. The House of Delegates in St. Louis, however, is considering a bill introduced by delegate Mohan, which fixes the rental of telephones in that city at $50 per annum.

The natural gas excitement, which never reached a very high pitch, has about died out. The principal interest now centres in the project to pipe the natural gas from the Indiana wells. The nearest wells of sufficient capacity to supply Chicago are at Muncie, Indiana, about 150 miles away. The plan of piping the natural gas this distance is seriously discussed, although the cost of such an undertaking would be enormous. In the meantime continual prospecting is going on at points nearer Chicago, but so far without very encouraging results.

CHICAGO, Feb. 20, 1888.

ELECTRICAL NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF FEBRUARY 14.

The president, Mr. T. Commerford Martin, occupied the chair.

Mr. R. W. Pope, secretary, made the following announcements.

At the regular monthly meeting of council, held December 6th, 1887, Dr. F. Benedict Herzog, president of the Herzog Teleseme Co., New York, was elected one of the managers of the Institute for the unexpired term of the late Sidney F. Shelbourne.

At the regular monthly meeting of council, held February 7th, Mr. John W. Howell, electrician of the Edison Lamp Co., Harrison, N. J., was elected one of the managers, to fill the unexpired term of Mr. William Lee Church, resigned.

The following named gentlemen were elected to associate membership in the Institute:

Professor W. D. Marks, Professor of Dynamical Engineering, University of Penn.

Sir David Salomons, Baronet, Tunbridge Wells, England.

Willard E. Case, Physicist, Auburn, N. Y.

Edward H. Johnson, President, Edison Electric Light Co., N. Y.

W. H. Wiley, Treasurer American Society of Mechanical Engineers, N. Y.

M. D. Law, President Philadelphia Electrical Society; Superintendent Brush Electrical Co., Philadelphia.

Montgomery Waddell, Superintendent of Underground Construction, Edison Machine Works, Schenectady, N. Y.

Gustav Pfannkuche, Electrician Brush Electric Co., Cleveland, O.

James Jerritt, Plymouth, England.

W. F. D. Crane, Electrical Engineering Department, Cornell University, Ithaca, N. Y.

Frank R. Harding, Patent Attorney and Elec. Expert, Washington, D. C.

The twenty-fourth meeting of the Institute will be held on Tuesday, March 13th, at which a paper will be read by Lieut. F. Jarvis Patten, entitled "Some Old and New Applications of the Alternating Current."

The President—Dr. Duncan is already so well known to a great many of us personally and to all of us by reputation, as to need no introduction. I will therefore ask him to proceed at once to read his paper on Alternating Current Motors.

Dr. Duncan then read his paper. (See page 85.)

DISCUSSION.

Mr. Wolcott—Dr. Duncan's paper throws a rather different light upon the subject of alternating current motors from that derived from the paper of Mr. Stanley. From Mr. Stanley's paper we concluded that the alternating system, all the way through, was slightly more economical than the direct. But Dr. Duncan has shown, I think pretty conclusively, that there are various losses there which we do not have in the direct system. The loss from heat, which depends upon the square of the current, I think is very neatly demonstrated;—the work depending on the product of the current and the electromotive force changing in sign whenever the electromotive force changes, while the loss in heat is constantly plus because the square of the minus quantity is plus. There is one advantage, I think, in the alternating system which is entirely of a practical nature irrespective of the efficiency, and that is that you do not use any commutator at all. I know one of the greatest practical difficulties in both motors and dynamos is the trouble due to commutators. Of course in favorable conditions of working, the commutator may last a long time without need of repair; but, as I have had reason to observe especially of late, in railroad work, the commutator gets used up pretty quickly in running street railways. If there is any possibility of running a street railway with an alternating current motor, I think it would be a great advantage even if it were not so economical as direct current motors. Even if it lost twenty-five or thirty per cent of the energy more than the direct motor, I think in some cases it would be preferable.

Mr. C. O. Mailloux—I would like to remark with respect to the application of alternating current distribution to the purposes of electrical traction, brought forward by Mr. Wolcott, that it will probably be some time before we succeed in utilizing it, however great may be the advantage of its use; because the alternating current motor fails to afford one of the chief requirements

demanded in a motor for electrical traction—namely, capacity for producing great torque or effort at the periphery of the armature at the time of starting. This is exactly what the alternating current will not do. Dr. Duncan has pointed out the necessity for gradually putting the load on, so to speak ; while as we know in electrical traction, it is necessary to develop large pulling capacity or effort at once. There is a great deal of confusion in that respect as to what is really required of a motor. You may rate a motor of a certain power, and it may be capable of giving you that energy when running at a certain stated speed, yet the motor may be for all that very far from answering the purposes which it must fulfill in traction, because at the time of starting the car the effort required is more static than anything else, and while in order to measure kinetic energy by the standards which we have of foot-pounds we must have motion and pressure, or feet and pounds,—at the time of starting the car we have only pounds and not feet. In other words, it is a static, dead pull, and the motor must be capable of supplying that pull or else it cannot be expected to succeed in propelling a vehicle of any description ; and while a motor, might be capable of developing its nominal power and more than that when running at a given speed such as would propel the car at its rated miles per hour, yet it might prove quite inadequate at the time of starting, from the reason that it is not so organized as to be able to develop that effort at the periphery of the armature which is necessary to give the static pull ; and that is wherein the alternating current motor does not seem to me to give any hope, at least for the present, and for a considerable portion of the future ; because we would have to use machinery, such as friction clutches and various other devices of that kind so as to gradually apply the work to the motor.

Mr. F. B. Crocker—There are two or three practical points that suggest themselves to me. In the first place, Dr. Duncan mentions the great cost of laminated field cores, and he speaks of it as if it were practically a bar to the use of laminated fields. If I were going to make a wrought iron field—if I were bidding for a contract to make wrought iron fields, I would prefer to make them laminated rather than make them of forgins.

In respect to putting on a load suddenly, that is a difficulty no doubt, and a serious one ; but still the load does not go on with the mathematical suddenness that Dr. Duncan speaks of. The belt will squeak, there will be a smell and the load will gradually come on, and in ordinary cases where the load is great, but not very great, it will come on gradually, the motor will take it and run along with it. Of course that is a question of degree ; in some cases it would—in some cases it would not.

Mr. Mailloux pointed out the difficulty of applying alternating current motors to car traction—they have not the torque, they have not the snap to them that the continuous current motor has, so far ; and the problem is to increase their effect—make them more powerful with respect to their size. The same holds good, more or less of alternating current dynamos, I believe. They are large and clumsy for their output. But alternating current motors of the two classes that start themselves are still more clumsy and large for their weights, and those are the two classes which I look to as being the ones to improve and to get into practical shape.

Mr. Mailloux—Those alternating motors which would be able to start themselves and which Mr. Crocker thinks might be able to develop the torque required are the very ones which are no longer free from the disadvantages of devices for commutating and other troubles of that kind which are incident to the continuous current motor.

Now as to the torque production, I think that the objection still holds good, because the trouble of heating as it is related in some way to self-induction—or, at least the production of eddy currents in the mass of the iron itself, even though it be eliminated, still applies ; and as in order to produce a powerful effort at the periphery of the armature it is necessary to increase the current very largely, I doubt very much if the curve of torque would be such as you would obtain from a continuous current motor. I fear that it would not rise so quickly and that it would reach the limit very much sooner. Then, besides, I do not see how it would be possible, with the present resources of the art to regulate the current so as to render the use of the motor for that purpose as elastic as the continuous current motor, because there are a number of limitations or conditions imposed by the current itself which are very hard to overcome.

Lieutenant Patten—Dr. Duncan has shown us that the curve of counter-electromotive force has a variable position with respect to mean—oscillating from side to side—and I wish to ask for information whether any such oscillation takes place or not provided the motor is running under a constant load.

Dr. Duncan—I think the oscillation certainly would take place no matter what load is on the motor ; because in a part of every period—and a period takes up only $\frac{1}{300}$th of a second, the motor is not a motor at all, it is a dynamo. That is it is absolutely putting current into the main line. The only way to get the energy and throw that current into the main line is by decreasing its speed and drawing from its energy of rotation. Therefore, where it is in those areas it will slow down in speed. Where it is in the larger areas it will increase its speed. But the oscillation will occur whether the load is constant or not.

Lieutenant Patten—The question is fully answered with a single exception, regarding the high number of alternations. I would presume that the oscillation referred to is infinitesimal in its character and would make no difference in the practical regulation of the motor in a finite amount of time.

Dr. Duncan—If the motor were driving a load which had a considerable inertia—any revolving apparatus which had a considerable inertia compared with the amount of work, the amount of the oscillation would be infinitesimal. But if the motor were light and were lifting a heavy weight, then the amount of oscillation would be very noticeable and would seriously decrease the maximum work which the motor could do.

Mr. Crocker here made mention of recent successful experiments that he had made in regulating alternate current motors and obviating excessive sparking, but did not describe them.

Mr. S. S. Wheeler—There has been considerable discussion about the torque of an alternating current motor, and Mr. Mailloux prefers the direct current motor for car traction, because when the car is going slowly, or starting, the motor going slowly will draw a heavier current and will give a tremendous power momentarily. There are two classes of direct current motors, one of which does not increase its torque when the speed is slow, and the other does increase its torque—the constant current and the constant potential motors. The alternating motors which have been described seem to resemble the constant current motors in having a constant torque. I would like to ask Dr. Duncan to give us a little information about what can be done in shifting the proportions or changing the design of alternating current motors to make them resemble more closely the constant potential motors so that greater torque will be secured at low speeds.

Lieutenant Patten (who had previously arisen and drawn upon the blackboard the figures below)—I have designed a form and made some elementary tests of a motor of the kind suggested by Professor Thomson in his paper last spring. I have always regarded Professor Thomson's motor with a great deal of admiration. It would seem from some of the discussions we have listened to that whatever work we are going to get out of an alternating system must be a question of difference between two factors opposed

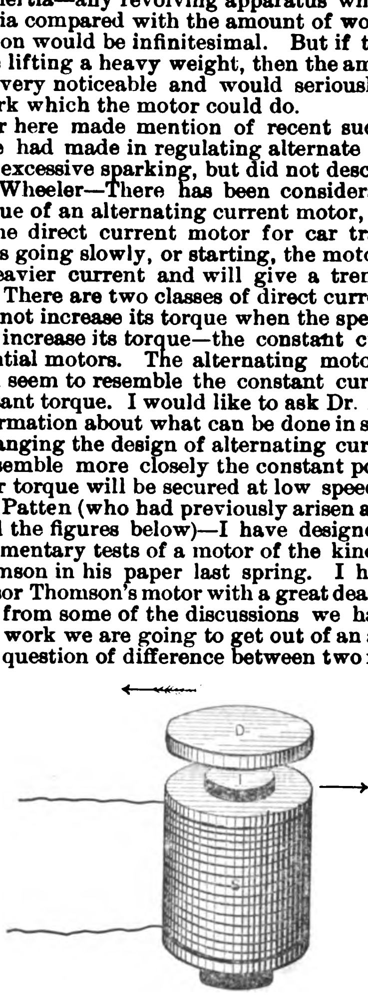

FIG. 1.

to each other—the self-induction of the circuit and the power generated as well as the heating. Inasmuch as all our results must be due to the difference between the two quantities, I have worked upon that line, trying to give that difference its greatest possible chance to do some work. If you will remember, Professor Thomson's motor, as Dr. Duncan has explained it to-night, consists in a fixed field, and a revolving armature, the circuit of which was closed when it came into position of action ; at that point the circuit is momentarily closed. But it seems that the Professor has adhered a little too closely to the ordinary form of motors. We are apt to stick to elementary ideas in applying new principles. The Professor undoubtedly elucidated a new principle, but I think it should be applied in a new way ; that is, inasmuch as the effort—the rotary torque to be used there is due to the difference in action, instead of a sudden push or pull, it should be applied so that it would have that effect. The principle you all remember. Figure 1 shows a solenoid with an iron core, and a closed circuit of high self-inductive capacity. The alternating currents are sent through the solenoid. There is an action tending to separate these two parts, either in the direction of the arrow, or the opposite, according to circumstances ; and inasmuch as this is due to electro-inductive repulsion, as described by Professor Thomson, and is due to the difference of two efforts, we can hardly expect it to be great ; and for that reason, instead of putting this force where it works at a slight advantage, in my design I propose to put it where it will work at a maximum advantage. Figure 2 will represent an end view of the machine which I designed. This is the axis of the machine, and about it are arranged two sets of four solenoids. I have numbered them from one to eight. The even numbered ones are all arranged in one plane ; the other ones in another plane, secured to the same spindle. Figure 3 is a side view of the machine. Arranged around the periphery are the closed circuits—copper discs D, D, D, D. These discs are put as far as we can carry them from the axis of rotation without increasing the size of the machine. The purpose of this is to put the action thus genera-

ted as far from the spindle as possible. There are two sets of these copper discs as shown here in side representation, and these sets of solenoids arranged on a spindle here are so connected that they come alternately into action, Just, for instance, as 1, 3, 5 and 7 are passing these four discs, the commutator throws the alternating current through that set. The other set, which then has no current comes into action in the same manner. The result is that there is a continuous torque exerted at a distance from the spindle where it can act with some advantage. The circuits of the machines are shown here. This is the connector through which the current enters the machine. These represent on each side the four coils in each of these series. Here are four coils—2, 4, 6 and 8, connected in series, and on this side the odd ones similarly connected in series. The other terminal of the machine is an ordinary eight part commutator, to which alternating parts these series are connected in alternations. The trailing brush then sweeping over this turns the alternating current into these different sets alternately. The result is we have a machine in which there is a con-

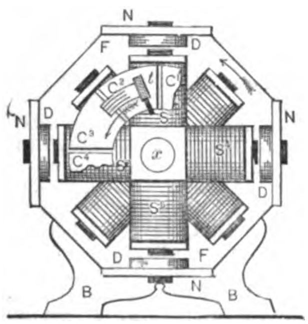

FIG. 2.

tinuous effort. I have illustrated merely the principle. These may be increased in number indefinitely and the rotary torque of such a machine would be as constant at its starting point as at any other time. I have got fairly good results from the elementary test.

Mr. R. M. Hunter informed the meeting that he had successfully met many of the difficulties that had been pointed out in alternating current motors, but gave no description of his machines.

Mr. Waring—I fail to perceive the particular advantage in running street cars or of applying alternating currents for the transmission of power. We all know that its particular advantage in incandescent lighting lies in the fact that we cannot use lamps of any higher potential than 100 volts, unless we use them in series, of course, and at the present stage of the art of electric transmission of power it is not practicable to transmit power—even continuous currents—at any higher electromotive force than probably 500, or, I should say, at a maximum, especially in street railways with central conductors or overhead conductors, of over 700

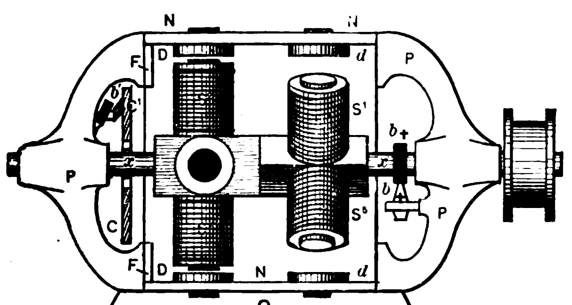

FIG. 3.

volts potential. Therefore I would like to say that I cannot see any particular advantage in using an alternating current when a continuous current will do.

Mr. Wheeler—I would like to have Dr. Duncan tell us something about the comparison of the torque of the alternating current motor with the direct constant current and the direct constant potential motors, if he is willing.

Dr. Duncan—With regard to using these alternating currents for street cars, I myself, with Mr. Waring, cannot see the advisability of using them at present, till we know a good deal more about them, while we have continuous current motors which I think are at present very much better.

With respect to the torque of the alternating motor it will be the maximum when the period of the electromotive force is the same as the period of the counter-electromotive force. For instance, if you have two curves (illustrating) that represents the curve of the main line or the curve of the dynamo which is supplying the car. Now we cannot get a greater maximum than by using a curve whose period is the same as this (illustrating) or whose phase is also very nearly the same. If we took a number of reversals that way, of course the product would be very much less. The greatest torque will be then when the reversals of the electromotive force—we call this the electromotive force—are the same as the reversals of the current; that is when the motor is at its normal speed. Of course, for street car work we want to start at a very slow speed, and there, with an ordinary type of alternating motor—I do not refer to any special types which have been brought forward and more or less described—but with an ordinary type of alternating motor the torque at first is very small indeed; and again, if we are to feed our motor from a determined source of power I do not see myself how we can make torque great at a slow speed. Of course if we make the current an alternating current then the period of our alternation of electromotive force and counter-electromotive force we can make the same, no matter what speed we use. But if we are to drive that motor from a dynamo that has a sudden and rapid number of reversals I cannot see that the torque will be great unless the dynamo has in reality reached its maximum speed. For the maximum work which can be obtained from an alternating motor, Mr. Hutchinson has kindly worked out the problem and finds that if we make the ordinary suppositions and work the motor at its maximum the expression for maximum work is a very simple one—E square divided by 8 R, where E is the maximum value of the electromotive force and R is the resistance of the machine. It is independent of the self-induction and of any other data. There are conditions which Mr. Hutchinson finds in his equations which will enable us to design a machine to give this maximum work. After we have designed it, the maximum work to be obtained is E square divided by 8 R. That is about one-fourth of the work that would be obtained from the same source by a continuous current motor.

There is another very curious thing; in order to get the maximum work from a motor which we obtain from a Siemens alternating dynamo, the counter-electromotive force is greater than the electromotive force of the dynamo. If the electromotive force of the dynamo is one thousand volts we find that the counter-electromotive force is almost fifteen hundred volts. That being the fact, the work, as I said, is E square divided by 8 R, which is about one-fourth of the work of a continuous current machine, put between the same mains made in the same way? The torque, as I said, would be greatest when the machine is running at its full number of revolutions.

Mr. Crocker speaks of a machine, when a load is suddenly thrown on, gradually bringing it up to its maximum, and the belt squeaking. If he tries the experiment he will not find the belt squeak, but it will suddenly stop; because unless that load is brought up to its full number of revolutions, in one period of reversal, in the Westinghouse system, in $\frac{1}{300}$ of a second, the motor will stop. Of course some arrangement has to be devised to stop that. He speaks of only using these motors where the maximum load will not be thrown on suddenly. Of course that is limiting the use in such a way that the motors could hardly be commercially applied.

I cannot see that an alternating motor such as I have described, that is a dynamo working backwards with a continuous current to start it and inside the field, will be at once practical. You might say that it complicates it by putting a commutator upon it. But the commutator is of the simplest kind. There is no wear of the brushes except in starting it, because after the machine is started the brushes are raised, and when it has reached its full number of revolutions you have no wear of the commutator or sparking at all. Of course that is the time we have the greatest amount of work.

Lieutenant Patten has brought forward a very interesting form of machine, a modification of Professor Thomson's plan, which we cannot but regard with the greatest admiration. The difficulty, as I can see it now, in such a machine as this is, that, as I understand it, Lieutenant Patten has revolving electro-magnets that come opposite copper pieces. Am I right?

Lieutenant Patten—That is the idea.

Dr. Duncan—The only difficulty in that is that currents will be induced in those copper pieces in order to cause the revolution of the armature. Now what becomes of the energy of those currents? Evidently it is lost in heat. If the energy of rotation of the motors is very great, the current induced in those pieces of copper is great. Therefore the loss must be great. For myself, I think that the two probable forms of motor are the motor I have described and some modification of Professor Thomson's motor. Whether Lieutenant Patten has arrived at that modification I do not know and of course cannot tell without further data and experiment.

Mr. Crocker again speaks of the sparking of the alternating motor being a minimum when it is regulated. I do not believe in alternating motors that have commutators, as they are ordinarily called—that is where they have a number of bars through which the current is constantly flowing. I have tried experiments with continuous current dynamos worked as motors and find very little effect from them. In order to get a large output

we have to have the counter-electromotive force of the motor equal to the self-induction of the motor, field magnets and armature, and that is simply impossible in practice. If you join up a series motor that has an alternating source of electromotive force, and then a continuous source of electromotive force, both five horse-power machines, in the alternating machine you can stop it by just laying your hand on it. With the continuous current machine, of course, you have an immense power there.

With regard to laminating the cores of the fields, I am very glad to hear that it is a non-expensive process. I have no doubt, if that is the case, it would have a distinct advantage in alternating dynamos of every class, because the alternations of current in the armature must cause certain induced currents in the poles, and if we can build a laminated pole more easily than we can a forged pole, I think it would be policy to make all our poles laminated. However, I have had no experience in that at all and can hardly discuss it.

Mr. Waring made some remarks which embody my sentiments with regard to using alternating current motors for street cars. I do not see the use of an alternating current motor on a street car. The power of doing work is about one-fourth the power of a continuous current motor, and the only difficulty in a continuous current motor lies in the commutator—in the brushes. There is trouble, I suppose, when the car goes both ways. Now that is a matter of detail, and with properly constructed brushes there should be very little trouble. If the commutator bars were made hard enough we would have very little wear. If they were made properly we have absolutely no sparking. I think I saw somewhere a reference by Dr. Hopkinson to a method of preventing sparking. It is well known in laboratory work. I will illustrate it briefly (making a sketch). This is our brush bridge over that coil. We have a current in the short circuited coil. The current comes up here, goes through that coil, goes through the brush out of the main circuit. This coil is short circuited. Now when that coil reaches this position the short circuited coil is suddenly thrown into the main circuit. The effect of that is to suddenly change its current, if its current in this position is not exactly the same as half the current in the main line. Now a change of current taking place in an infinitely short time, it would develop an infinitely high electromotive force. It does not take place in that time, but rectifies itself by having a small spark going across and the current being still partially short circuited. That can be obviated by having behind this brush another brush—the resistance between this brush and the circuit being four or five ohms, or something of the kind. Then the current will rectify itself by passing through that auxiliary brush, and though some energy will be lost, still not more than in the sparking and wear of the armature.

I think these are all the questions that have been asked, and I will say again that I have a firm faith in the ultimate doctrine of alternating current motors, and I think that the two forms to which we must look for results are either simply the dynamo reversed, such as I have suggested, or some modification of Professor Thomson's dynamo. (Applause.)

The President—It must be a source of great gratification to all members of the Institute to see from the records of the society how far the papers which have been brought before us during the past year have served as the basis of those very interesting and important investigations into the subject of alternating currents. The paper which we have had before us this evening is a very valuable contribution to the literature of the subject and it has afforded us all very great pleasure and profit to listen to it.

The author of the paper to be read before us at the next meeting will be Lieutenant F. Jarvis Patten.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

ANNUAL MEETING (SIXTH SEMI-ANNUAL) PITTSBURGH, PA., FEBRUARY 21-23, 1888.

THE meeting was called to order at 12 M., February 21, at the Monongahela House, the President, Mr. J. Frank Morrison, occupying the chair.

The President addressed the convention as follows :—

Gentlemen of the convention :

When the National Electric Light Association, in its wisdom decreed that its next meeting should be held in this city, it was certainly an evidence of our faith in the stability of the business in which we are engaged.

The cheapest of coal, the natural gas,—every element that nature could furnish for illuminating purposes, are here spread out freely without money and without price.

To face these existing conditions, the electric light, which is comparatively expensive must have behind it the backing of nerve and courage and an unbounded faith in the good taste of the people of Pittsburgh, who, with its greater cost have adopted it in preference to that of its mighty competitors,—that light which not only illuminates but adorns their dwellings, their mercantile houses, and their public buildings.

Seven years ago the first electric light company was started in Pittsburgh with 14 arc lights. It struggled along against the prejudice, against time-honored usages, for six years, at which time 300 lights were burning where there had been but one. Here a new era opened, and within the short space of 18 months the electric lighting business increased to 350 arc, and 2,000 incandescent lights which now blaze in a constellation of glory, reflecting credit upon its progenitors. During the past six months we find that great progress has been made in cheapening the methods by which electric lighting is produced ; this is noticeably the case in the arc lighting business. The extension of arc lighting since our last meeting has been something marvelous, while even that has been outstripped by incandescent lighting, both by direct and alternating systems.

There are to-day in this country at least 3,000 isolated arc or incandescent plants, and over 1,000 central stations. At our last annual meeting there were in operation in the United States, approximately, 125,000 arc lights. Since that time there have been installed and contracted for probably 50,000, bringing the present actual total within the neighborhood of 175,000 arc lights.

The number of incandescent lights at our last meeting was slightly over a million and a quarter. The installations and contracts made since that time are reported to foot up nearly half a million, bringing the present total to about 1,750,000, giving, it will be noticed, on the whole business a proportion of about 10 incandescent to one arc. These are statistics which exhibit extraordinary growth and yet are conservatively estimated.

I beg again to urge upon the members of this association, the necessity of intelligent and well directed efforts toward the more perfect construction of lines and installation of apparatus. While some fatal accidents have marred the record of the past six months, I am glad to say that they have been fewer in number and less chargeable to the danger of the system itself than have been similar casualities in any other calling that involves the use of power-driven machinery. The attendance at this meeting is sufficient evidence of the success of this association. The secretary's report shows a membership of 168. By reference to the report of the treasurer, we find that a fairly good financial showing is made. With a debt of only $98, and with $971 in the treasury to cover all expenses of the present fiscal year, we need have no fears on that score.

Considerable progress has been made by Arthur Steuart, chairman of the legal committee toward bettering our condition in the patent office. This is a matter to which your attention will be strongly directed during the present convention, and I ask for it your calm and careful consideration. You will be called upon to decide whether or not further steps shall be taken in the direction already pursued. I am seriously of the opinion that for the better protection of those engaged in the electric lighting whose first investments depend largely upon the validity of their patents, we should, if it is possible to do so, prosecute to a successful conclusion a work so well begun by the legal committee.

Papers will be read as follows: on "The Practical Side of the Distribution of Alternating Currents from Central Stations," Mr. T. C. Smith, Pittsburgh ; on "Underground Conduits for Arc Light Wires," Mr. W. W. Leggett and Mr. Jesse M. Smith, Detroit ; on "Electric Motors," Dr. G. A. Liebig, Baltimore ; on "The Economic Value of Steam Pressure Records," Jarvis B. Edson, M. E., New York ; on "Leather Belting," its Origin and Progress, Mr. Charles A. Schieren, New York ; on "Independent Engines, in Incandescent Light Stations," Mr. W. Lee Church, Pittsburgh ; on "How Can We Protect our Watches from Magnetic Influences?" Dr. Philip Lange, Pittsburgh.

Permit me to congratulate the association upon the excellent work done by Mr. Duncan, chairman of the executive committee, who has been so ably assisted by his colleagues, and who has shown his signal executive capacity by the excellent manner in which he has prepared for the prompt transaction of the business of the association, and for the comforts of its members.

President Morrison said further :—I desire to call your attention to one or two points which reflect a great deal of credit upon the citizens of our own country, and perhaps, to put it mildly, an implication of negligence on the part of those abroad. Statistics show that in this country we have 178,000 arc lamps in service and also a large number of incandescent lights. Now the question naturally arises, why should we have made such headway on this side of the Atlantic and why should the business have been practically at a standstill on the other side. The answer may be given in two words—vicious legislation. If one absolutely inimical to progress had planned out an act of parliament which would have absolutely quenched electric lights in Great Britain and Europe he could not have better succeeded than those who framed that infamous act known as the Parliamentary Lighting Act, which has paralyzed that industry in England, has smothered invention in that direction, and which finds its only vent in the spleen which casts slurs upon those of us on this side of the Atlantic who have been diligently engaged in furnishing this light which has been so popular amongst all classes of our people. A few years ago it was only the rich who could enjoy this luxury. To-day it is brought to the door of the poor man's house, and within a year or two more it will be the popular light which will not only take the place of the illumination by gas but will take the place of the coal oil lamp, and will be within the

reach of every one who is capable of reading and who wants light for that or any other purpose.

I now have the pleasure of introducing to you, Major W C. Moreland who will offer you the privileges of the city of Pittsburgh. Gentlemen of the Convention—Major Moreland.

Major Moreland then addressed the convention as follows :—

Mr. President and Gentlemen of the Convention : I have been requested by the Mayor of the city of Pittsburgh to give you a welcome to this city. To me it is a personal pleasure thus to speak—first, because I have a warm personal interest in all the men connected with the development of electricity in all of its branches, and because in this convention there sits a man who, 40 years ago, was my master and my instructor—taught me how to carry a telegraph line—how to make a splice ; taught me something about a magnet, a little about instruments and asked me on one occasion to go—not very far from where we are sitting—to see whether the lines were not broken between two poles, told me how I could test whether or no the connection existed between those two poles, by putting the two ends of the wire to my tongue. I did it, gentlemen, and fell over the hill. I sat opposite him when the first telegraphic communication between New York city and New Orleans passed over this part of the continent. I heard him say that he had carried the wires through the marshes of Louisana along through the whole of the south—my friend, David Brooks, the man who introduced electricity into the city of Pittsburgh and built the first lines through this region, connecting the extreme east and the extreme south. I have, in addition to that, gentlemen, a personal pleasure in asking your attention to the industries of the city of Pittsburgh. If you have leisure to examine them, they are worthy of your study, and we are glad that such a convention as this has assembled in our city. You have solved the great problem that was in the mind of Benjamin Franklin, who claimed that electricity was at last to be subordinated to the uses of man. You have brought it to our homes, you have brought it to our industries, and who can tell where with your industry, your talents, your perseverance, it may not be brought at last. It has now become not merely a commodity but a source of pleasure at our homes and fireside. Gentlemen, I have a personal pleasure in meeting you, not only because as an old electrician myself—that is to say a novice in electricity—but one who sympathizes with the progress made during the last 30 years, and secondly because you are right in the place where, of all other places, we want electricity practically applied. I know little about your purposes—but little about the progress your society has made ; but in the name of the city of Pittsburgh, as the representative of its mayor, I bid you a most hearty welcome.

The secretary read a letter from Mr. G S. Bowen, of Elgin, Ill., expressing his regret at being unable to attend the convention ; also a letter from Mr. F. C. Osborn, chairman of the committee on progress, of the Engineers' Society of Western Pennsylvania, inviting the members of the association to attend a meeting of that society at 8 o'clock in the evening.

It was agreed that the invitation be accepted, with the thanks of the association.

Mr. Duncan—I move further, sir, that an invitation be extended to the Engineers' Society of Western Pennsylvania to attend the sessions of this association during this convention, and participate, if they so desire, in its discussion. The motion was unanimously voted.

A letter was read from the Allegheny County Light Co., inviting the members of the association to visit the station of that company. On motion the invitation was accepted. A similar invitation from the Westinghouse Machine Co. was read and accepted.

A telegram was read from Mr. H. C. Davis, President of the Electric Club, of New York, tendering to the association the use of the club house in the event of their holding the next convention in the City of New York. Referred to committee on place of meeting.

A letter was read signed by several Westinghouse sub-companies enclosing a contribution by those companies of $1,150 "To encourage the best interests of the association."

The communication was, on motion, accepted with the thanks of the convention.

The secretary and treasurer read his report which, on motion, was accepted.

The report showed the following :

RECEIPTS.		
From Aug. 1, 1887, To balance....	$ 692.15	
To Receipts from Aug. 1, 1887, to Feb. 18, 1888.........	1,261.62	$1,953.77
DISBURSEMENTS.		
From Aug. 1, 1887, to February 18, 1888		982.10
Balance on hand..........		$971.67

The membership numbers 168.

The report of the chairman of the executive committee was read by Mr. Duncan, and received and ratified by the association.

The recommendation of the executive committee that members in arrears for dues shall be notified at once that they will be dropped from the rolls after the expiration of thirty days, if their dues were not paid, was, on motion, adopted.

Mr. S. A. Duncan—I submitted in writing, as provided by the constitution, and left with the secretary, an amendment to the constitution in regard to the question of dues. The dues at the present time are an initiation fee of $10 and yearly dues of $10. It is very evident to the members of this association that for some time past the association has omitted to have its reports printed, but the association has not had the funds to properly proceed with that work and to print them as they should be printed, in pamphlet form, and it is only at this meeting that our funds are in such shape that we could possibly proceed with the work. The matter had given rise to considerable debate and discussion, and in order that it might be brought properly before the association at the right time, I submit the following amendment to article 8 of the constitution : "That the yearly dues of the association shall be $20." I submit that as an amendment to article 8 of the constitution, and ask that it may lie over for consideration until to-morrow morning to be made the special order of business at our opening meeting to-morrow.

The President—Gentlemen, you have heard the proposed amendment to the constitution. Article 9 of the constitution prescribes that all amendments shall be presented in writing and referred to a committee to be appointed by the Chair before being acted upon by the association ; a two-thirds vote of those present shall be necessary to their adoption ; and that a ballot on such amendment may be called for upon the request of five members of the association. In pursuance of this provision, I will appoint as the committee on this amendment, Mr. Duncan, Dr. Moses and Mr. Weeks.

Mr. Duncan—Mr. Chairman, I desire to make the following motion which was unanimously recommended by the executive committee—that Professor George Forbes, of London, England, be elected an honorary member of this association.

Professor Forbes was unanimously elected.

Mr. E. T. Lynch, Jr.—I should like to make a motion for the appointment of a committee of five for the nomination of officers for the ensuing year, said committee also to make a recommendation as to the next place of meeting ; the committee to be appointed by the Chair. The motion was carried.

A brief report by the committee on the insulation of wires and construction of plant was read by the secretary.

A paper upon the same subject, by Professor Elihu Thomson, was read by Mr. Rice. (See page 90.)

The President—The paper is now before you for discussion.

Dr. Otto A. Moses—I have been informed that, in the absence of Professor Thomson, the President requests that I, as second on the list, shall speak to the question. I feel like quoting a passage that I think will reverberate in all your hearts : "The boy stood on the burning deck, whence all but him had fled." During the greater part of the time since the last meeting, I have been absent in Europe, whence I have but recently returned. I do not see another member of that committee. Within the last three days I received a communication from the chairman of the committee asking me for my opinion of the report which has just been read—asking my approval or disapproval. I gave neither the one nor the other, as the time was too short for him to receive my reply, and I expected to answer him at the convention. As he is not here and has kindly submitted to the convention a paper which embodies his own views on the subject, I believe that I should speak for the committee, since they appear derelict in their duty. It must be borne in mind that a committee of able men was appointed before this one was formed who did some preparatory work, but who declined to proceed further in the investigation without some funds to provide for experiments. But the President of our association, with his usual intuition, appointed a committee composed of men that had laboratories at their command. If my memory serves me, that committee consisted of Professor Thomson—we all know how admirably fitted up his laboratory is—of Professor Duncan, of Johns Hopkins' University—we know how much care and time Professor Rowland and himself have spent on their laboratory ; Mr. Hamilton, of the Western Union Telegraph Company, who has charge of the testing outfit of that company ; Mr. Lockwood, of the Bell Telephone Company, known to you all by his writings and his investigations in telephony ; Dr. Waldo, who has had several university laboratories under his command, and Mr. Shallenberger, of the Westinghouse Electric Company. Thus all the different requirements of installation would be properly represented in the committee. The committee was formed for the purpose of getting an exhaustive report. Now the reasons that have been advanced by the chairman of the committee are valid in some respects ; yet, as I only received a communication but two days before the meeting of the convention asking my opinion on the subject, I am led to believe—though I have no absolute reason for saying so—that other members of the committee may be in exactly the same position as myself. They may not have received sufficient notice to enable them to give the report the attention it deserves. I do not feel as if that committee should be discharged. I would suggest that the Chair should be requested to re-appoint

them. Every member of that committee is able to do good work, and I hope that the next report of this convention, will include a report on insulation that will be of benefit to this convention, and that will be somewhat of an honor to American electricians for its thoroughness and fullness.

Mr. DeCamp—I agree with Dr. Moses that that committee should be continued. There is much in the subject for discussion which may be brought out in a paper to be presented to the association before the close of this meeting which the members of this committee will have the benefit of. There is a great deal in the report which will be pertinent to our underground wire discussions. I will therefore move that the committee be continued as it is, to report at the next meeting of the association. The motion was carried.

Mr. Wells Leggett—I wish to point out the effect upon a lead-covered cable of a short kink in the cable or of a dent in the lead—the compression of the insulation, whereby it is rendered a shorter conductor, so that at such a point there is a better opportunity for the current to leak out. I suppose that has occurred again and again in the experience of members of the committee.

Professor Thomson refers to the potential of the alternating current and its relation to the insulation required, raising the question, whether or no, in alternating currents, the potential instead of being one thousand volts is not practically five hundred volts in respect to its action on the insulation—whether or no the insulation is not required to confine a current of five hundred volts, rather than one thousand—whether it is not an average between no current and full current, and whether that does not account for the fact, as I understand, that with the Westinghouse alternating current underground lead covered conductors have been employed with good results.

Mr. Rice—If I am allowed to answer Mr. Leggett on that point I would say it is just about the other way. The potential that the insulator has to stand on a thousand volt alternating circuit is nearly two thousand volts—just about double that of a direct current. When you say 2,000 volts it means an average of one thousand volts. Perhaps the reason we do not have any more current with alternations than the direct is that there is no active kick to speak of on a disruption of the line. Whereas with a direct current there is quite a kick.

Dr. Moses—It seems a mere hypothesis that the potential rises to two thousand volts, because, in measuring those currents—Mr. Rice will bear me me out—that he has never seen indications with an alternating current of 1,000 volts potential. It therefore appears to simply become a hypothesis.

Some further remarks were made by Dr. Moses and Mr. Leggett upon the compression of the insulation in lead covered cables by short bends.

Mr. DeCamp—I cannot claim any practical or theoretical knowledge as to this alternating current. I will simply put myself in the position of an asker of questions. I have generally understood that one of the difficulties in maintaining perfect insulation with direct currents is in obtaining insulation to cover a given number of volts and to provide against what I understand is the reactionary current arising from various causes. Dr. Moses states, and therein agrees with Mr. Rice, that the alternating current runs from zero to two thousand volts.

The President—Mr. Rice stated that the current ran from zero to two thousand volts, but Dr. Moses stated that was an hypothesis, and that there was no proof of it.

Dr. Moses—We stand as to that, as Faraday says we always should stand in the face of an hypothesis—with suspended judgment.

Mr. DeCamp—Slight intermissions of currents are sure to attend any reactionary currents which are, intentionally or otherwise, created on a circuit. It just occurred to me that this alternating current is of that nature, that is a constantly reactionary current; and hence my conclusion would be that the difficulty of insulating against that kind of current would be greater than that of insulating against a constant current.

Mr. Eustis—With regard to underground wires I wish to mention a little result that came to my notice some time since, which may be of some use to the convention. In Professor Thomson's paper he states that after the cables are once laid they are then not liable to be disturbed, owing to the mechanical covering outside. But I know of one particular case in which the insulating wires were laid in a conduit, by a railroad track, in a box about six inches square. Three or four wires were laid in that loosely. Every time it rained the water from the side of the tracks washed more or less through this conduit, and carried with it, I presume, some sand. At all events, after the wires had been laid there about two years the insulation was found to be destroyed; and on drawing the cables out it was found to be due almost entirely, as far as outside appearance went, to the purely mechanical injury. The only explanation that I can see for that was the fact that as the heavy trains went over this conduit they compressed the ground, and the cables being laid as it were suspended—owing to its own stiffness—the two wires slipped by each other and gradually chafed the face of the two wires, one upon the other, and cut the insulation through. If any one has had a similar experience I think it would be a benefit to the association if he would state it.

Dr. Moses—I would like to ask if those wires were suspended or laid on the board.

Mr. Eustis—They were simply laid loose.

Dr. Moses—But only holding their own weight?

Mr. Eustis—They were thrown into this box loosely; and they were undoubtedly full of kinks My idea is that, as the box gave from the weight of the trains, the wires being loose in the box, because of its own stiffness, would spring against one another, the two wires bending differently.

Dr. Moses called attention to several instances of the great effects of oft-repeated concussions, and mentioned as an instance of the results of the continued application of even a small force, the experiment of the bullet and the cake of wax or resin, through which it is slowly forced by the action of gravity.

Mr. Eustis—In the case that I have referred to the abrasion takes place for lengths of about six inches or twelve inches, at different places throughout the whole length of the wire, and extending a distance of something like fifty feet. There would be places eight inches in length, where the outside covering was completely chafed through, evidently from some change of that kind. What it is caused by we do not know. In other places the insulation was perfectly intact.

Mr. David Brooks—This slight jar or concussion can only be seen after a time. This matter was brought to my notice the other day by the Pennsylvania Railroad Company. They had laid three cables in a wooden box along their railroad track. The boxes are four inches square, and fastened or closed; but it was found after awhile that the cables began to give way. They opened the boxes and they found that where they were laid on the bottom board of the box the cables had worked, by reason of this jar, about half-way through the board, and it had taken the covering off, greatly to their surprise, so that the insulation was interrupted. I have heard that in London, where they run the pipes on the overhead ways, even on those made of bricks or of solid masonry, this continued jar will in time begin to affect them. So that it is well, when anything of that kind is laid, to have it away from anything like concussion, although the concussion may be but small in amount.

Mr. Sperry—Inasmuch as we have Mr. Sunny here with us today, and he has a large experience in handling high potential currents underground, and as this matter of insulation is a very important matter, and anybody who can give us light upon it should be heard, I would suggest that he give us the benefit of his experience.

Mr. Sunny—My connection with the electric light business has only been for a short period, and I do not know that I am sufficiently acquainted with it to speak on the subject. We have had some experience with underground cables, and I have made some memoranda indicating the results of our experience, which I intend to present when the discussion of underground cables comes up, as I understand it will in a day or two. I would like to state, however, in reply to Mr. Leggett's question as to the effect of a dent in a lead cable, what the effects are upon insulation. We have to-day a large number of burn-outs in our lead covered cables, and I have been investigating a few of them, and I find, as a rule, the cable has burned out at a point where the surface was perfectly true, and where there were no indications of mechanical injury. On the other hand, in pulling out cables which have been destroyed we have found portions of them where the mechanical injuries have been so great as to completely clean the lead off the insulation, leaving the lead bared. There was no indication, at the point where the lead was bared off, that any leak of the current occurred at that point. The facts that I have embodied in this short report are at the pleasure of the convention.

The President—A paper on underground systems will be presented by Mr. Leggett, and another, as I understand, by Mr. J. C. Smith; and this discussion will more properly come up after the presentation of those papers. The paper of Dr. Lange is next in order. As he is not here I would like Mr. Martin to read it. (For Mr. Lange's paper see page 100.)

Dr. Moses—At the last meeting of the association this topic was introduced as a very important matter; and we are glad to know that Mr. Lange has been able to give us a means of overcoming the difficulty which is at once so thorough, so simple and so ingenious. The other day I had occasion to speak to a friend about an experiment that I had tried on the previous evening. I was in my bedroom, and took my watch off to place it upon the bureau, where there was a little compass belonging to one of my children; and I thought to myself that I would see whether the watch, which was said to be protected by a magnetic shield, would affect the magnet. Fortunately for the experiment as I moved the watch toward one of the poles it was repelled, and thus absolutely proved that there was a permanent polarity somewhere in my watch. Had it been simply a mass of iron that acted upon the poles of the compass magnet it would have attracted it to either pole; but the repulsion was proof to me of the magnetic polarity of some part of my watch. This watch of mine has given me a great deal of concern. It was presented to me on my 21st birthday, and I will do anything in the world to demagnetize it. In 1881, while at the Paris Exposition, I mentioned it to Mr. Varley; and he very kindly took it to an Edison dynamo, and

turned it round in a way to reverse the polarity, which is equivalent to alternating the current, until he got away some distance from it; but still he did not demagnetize the watch. I could not understand the reason of this, but explained it to myself in this way: That there was a certain amount of magnetism in my watch, every part of it being of steel, and that certain of these parts were lying parallel to the lines of force at a given time, and that they attracted the magnetism, and acted upon the hair spring and balance wheel. But, to continue the statement of my experiment: I mentioned that to one of my intelligent friends in New York, and he said, "Show me that, because I believe that my watch is taken in the same way. It stopped suddenly last night, and this morning went on again." I thought it a very important matter if we could manage to get our time-pieces going regularly. So I said, "Let us see what is the reason." Said he, "I opened the case, some time ago, to see what was the matter. I found that the watch had stopped, and in order to see what was in the watch to make it stop, I opened it with my pocket knife, and perhaps my knife was magnetic." Said I, "Let us try it." So we took a needle, and floated it on a cork on water—that being a delicate compass needle with which to test for magnetism. He applied his pen knife to it but it did not work at all. So I said, "Who made your knife?" He said, "Rodgers." Said I, "I guess it is a pewter knife." "No," said he, "it is a steel knife." I looked at it, and sure enough, there was Rodgers' marks upon it. I thought that I would show him how the needle would whirl around if a magnet was made to approach it, and so I took my knife, which I knew to have been made magnetic by one of my children a short time before; and I brought that knife near the needle, but it did not budge. Said he, "I guess yours is a pewter knife." I said, "Not at all; it is a Rodgers' knife, too." I thought to myself, "How is this?" I recollected that only the day before I had been near the poles of an alternating current machine. I had not tripped over it—as a certain gentleman says he tripped over a machine, and was thrown 15 feet away—but I was merely in the neighborhood of it; and probably my knife had been demagnetized in that way. The observations made by Mr. Lange in his paper more and more impress upon me the absolutely essential character of alternating currents for all distribution of electricity where we have to depend for life, or the safety of property, upon the compass needle. I think that that paper points to the abandonment of the continuous current distribution of electricity on board steamships. That is a very broad saying; but I think it will be proven, or supported by the facts that he has mentioned, and that as soon as the attention of the owners of steamship lines is called to it they will investigate the matter and verify the statement by experiments, and that the result will be a change from continuous current machines to machines producing alternating currents. That is a most important thing, and may be the means of saving many lives. I have had opportunity recently to see something of the carelessness of the officers and sailors on shipboard in respect to handling the electric light wires when they are being moved out of the way. They do not consider the action of the currents upon the compasses. It is a most important thing that we should get rid of the possibility of the action of currents upon compasses, particularly at times of danger. I think that the paper which has been read will prove one of the most instructive to be found in our annual proceedings.

Mr. Law—I quite agree with Mr. Lange in his conclusions, and I may state that I have been considerably troubled with my watch. It has a shield on it; and I will guarantee that if placed side by side with any watch in the room it will interfere with that watch's movement. I mean, any watch not properly protected. I have had considerable experience since the time of the electrical exhibition in Philadelphia. While there I demagnetized hundreds of watches by the old process of spinning them between the poles of the dynamo; but I had to be very careful in doing that not to do it as a man did who came into the station one night, and said, "I would like to demagnetize my watch;" and he held it out to the dynamo—and soon after he had to pick it up all around the room. I went through that precise experiment last week with Professor Houston, and the remarks which he made I wish to call to the attention of those who are investigating this subject. I will not state them in detail, but they refer to the old experiment of turning a copper disc between the poles of an electro-magnet. That copper disc will produce currents, and is called, I believe, Barlow's wheel. The supposition was that although the balance wheel of the watch was made of purely non-magnetic material, still if placed between the poles of the dynamo their influence would affect the balance wheel the same as it did Barlow's wheel. The first experiment was to place the watch in the safe at the works for three weeks. It was a watch manufactured by one of our largest watch-making concerns in the country, and it was purely non-magnetic. The action was perfect. It was timed every day by a reputable watchmaker. This watch was placed on the poles of a 20-light Weston machine and remained there for five minutes without any effect. My own watch was placed by the side of it, and instantly stopped. Then the watch was placed between the poles of an Arnoux-Hochhausen dynamo—a 30-light machine. The armature was taken out, and the watch braced up by wooden blocks, so as to come right between the poles of the magnet, and directly in the strongest line of the force. We put that dynamo in a Daft circuit; the watch was placed in and allowed to remain there one hour. It lost fifteen seconds during the time. But understand, gentlemen, that the influence of the dynamo in this case was far more powerful than the watch would ever be called upon to sustain in ordinary use. I wish to call the attention of those present to this old principle of Barlow's wheel with a view of ascertaining if they have discovered any action on a balance wheel of non-magnetic metal.

Dr. Moses—I wish to call attention to an early experiment of Faraday's. He found that the needle of his compass, a short needle, oscillated too quickly. Thereupon he had a heavy brass plate put under it. The needle diminished its oscillations about one-half in a given time, showing the influence of a solid mass of metal upon it. It thus appears no mass of metal oscillating in a magnetic field will retain the same number of oscillations per second that it had before it came into that field.

Mr. Garratt—I confess that Dr. Moses has somewhat frightened me; and I think that perhaps any one who has occasion to go down to the sea in ships, and to do business in the great waters, might well feel alarmed if he were to assume that the great vessels, which are built of iron, which cross the ocean with their freight of thousands of lives and millions of dollars' worth of property, stood in any very great danger by reason of the electrical appliances which they now carry. I know nothing whatever from personal experience about the effect of dynamos and currents, and more especially the induced effect of currents upon navigation; but I am informed by a friend, an engineer of experience, and in whom I have confidence, that in some of the great ships which contain a ramification of wires, there has never been found exerted any influence whatever upon the compasses by the electric plant which lights the ship, and does a part of the mechanical work upon it. In saying that, I do not wish in any way to reflect upon what Dr. Moses says in regard to the value of using alternating currents where they can be so used on board ship, or in other places where we must rely upon the magnetic needle; but it does not seem to me wise that it should go out from this convention that the present electrical apparatus in use upon steamships constitutes an element of great danger. On board the steamship *Trenton* the curves of that ship and its magnet were worked out almost every day for a time after the electrical appliances were put on board; but no variation of the compass needle, or of the magnetism of the ship itself, or of any part of it, so far as the engineers who carefully investigated the matters, were able to discover, resulted from the dynamo plant which the ship carried. I want to again say that I do not intend that statement as a criticism or reflection upon what we all must recognize to be the very valuable remarks made by Dr. Moses; only I want to suggest that we are not in any great danger, the next time we want tocross the Atlantic, of fetching up somewhere near Sandy Hook after we have started for Liverpool, simply because we have a dynamo on board the ship.

Mr. Sperry—I would like to ask the last speaker if it is not a fact that those compasses are provided with heavy masses of metal, thus forming a magnetic shield around the compass.

Mr. Garratt—I would be most happy to inform the gentleman, but he must remember that I put a saving clause in my remarks, and that was that I knew nothing whatever about the subject upon which I was speaking.

The President—In order to reply to Mr. Sperry's question, I will ask Mr. Colvin, who was an officer on board the *Trenton*, to state what the fact is.

Mr. Colvin—On most ships the compasses are surrounded by a mass of metal which acts as a shield. In the case of the *Trenton* (and I was aboard of her for some time) I had occasion to work out the deviations of the compass, and they were worked out on this side as they were in the Mediterranean. We would swing ship and take the bearing of the sun on every point, and every half point sometimes, with the dynamo going, and then with the dynamo not going; with certain lights in, and certain lights out; with lights going in the pilot house, and lights not going in the pilot house. We had a torpedo apparatus there, of which I had charge; and the currents of that did not affect the compass at all. The ship's compass is composed of a number of needles of steel on the under side of a cardboard, and I never knew any variation in those curves that would amount to anything. The captain of the ship does not walk about the ship not knowing what his compass is doing. He knows more about that compass than he does of his own mind; and it is worked out every morning; and every morning the captain takes a sight for the longitude, and by that corrects any deviation of the compass, and so he is pretty safe.

Dr. Moses—I would like to ask our friend Colvin whether if a wire carrying the entire current from the dynamo that was competent to supply 500 15-candle Edison lamps were in that performance brought near to any one of the compasses upon which the captain depended—what would be the effect of that upon the compass—even though it might be surrounded by a very large mass of copper. Does he think that it would have no effect upon the deviation of the vessel from her course?

Mr. Colvin—In the case supposed by Dr. Moses the effect would be that the quartermaster forward, and the quartermaster aft

would notice that their compasses differed, and knowing that there was a difference the aft quartermaster would go forward and steer by the forward compass.

Dr. Moses—In case the entire crew, captain, passengers and all, are in the highest state of excitement in a dangerous emergency, is it likely that there would be at such a time any comparison of the accuracy of the compasses?

Mr. Colvin—On a properly constructed ship—I do not know how it is in the merchant service, for there they sometimes save a good deal of money by not employing competent people—but in the naval service there are usually three people looking at the compasses at once, the signal quartermaster and two assistant quartermasters.

As to your objection, I will state that in the vessels on which I have been there has never been any spar deck wiring on the upper deck; it has been done with buttons under the spar deck, and by the regulations of the department the compasses are put so far from any vertical wire, and so far from any horizontal wire; and the compass upon which they rely is usually some distance above the deck. All the other compasses could be lost or broken, and there would still be no danger on a properly equipped ship, that that particular compass remaining would vary so materially as to produce any disastrous effects. I am speaking now of the naval service; I know that sometimes in the merchant service things are perhaps carelessly or ignorantly done. Dr. Moses' suggestion is a very valuable one—about alternating currents, and one which I would take pleasure in communicating to the department, although I am not now connected with the service.

The President appointed as the committee, to nominate officers for the ensuing year, and to name the place for the next meeting of the association, the following: Eugene T. Lynch, Jr., E. R. Weeks, Frank Ridlon, H. D. Stanley, and A. V. Garratt.

In view of the acceptance of the invitation to attend the meeting of the Engineers' Society at eight o'clock in the evening, and of committee meetings to be held in the afternoon, the association adjourned until ten o'clock Wednesday morning.

WEDNESDAY MORNING SESSION, FEBRUARY 22.

The report of the Legal Committee was read by Mr. Arthur Steuart, of Baltimore, chairman, who said:

Mr. Steuart—I have the honor to make the report of the legal committee upon the question of improvements in our patent laws. The legal committee was constituted some years ago, and has been working along in an effort to arrive at some practical conclusion on the question of improvements in our patent system. We all know the intimate relation that exists between the electric lighting interests, and the patent system of this country; how closely they are related; and how much the growth of electrical interests is dependent upon the perfection of the patent system; and we all know from personal experience the serious defects and disadvantages that exist in the system as it is now administered.

Report of the Legal Committee on Reforms in the Patent Office.

In the several papers that have been presented to the association at its conventions by the legal committee, the following evils have been pointed out in the government of the patent office under the existing law and certain remedies suggested.

I. The staff of examiners in the patent office have charge of public interests of a most vital nature. They are the virtual judges of whether an inventor shall have a patent for his invention at all, and also of what kind of a patent he shall have in case they give him any.

It is therefore apparent that in order that they may perform their duties with intelligence and efficiency they must fulfill several conditions.

(a) They must be thoroughly educated in the technology of the arts and sciences and in the patent law. Experience has shown that this training can only be acquired in one or two ways—either by systematic teaching or by years of experience in the practical work of the patent office—the latter method is the one now in operation, and it results in creating a class of examiners who are undergoing the process of education at the expense of the unfortunate inventor whose case may fall into their hands. The inventors of the country have a right to demand that this system of education of examiners at their expense, be discontinued, and a system adopted that will secure to the patent office a corps of examiners who will be thoroughly trained before they enter the office, and to the inventor the examination of his case by a man fully equipped to make such examination in the best manner.

(b) Having obtained a staff of competent and thoroughly equipped examiners, they must be retained in office so that the public may have the benefit of their services through a number of years. The army and navy have long since solved this problem by the exercise of a system of education, compensation, promotion, and retirement on pay which fully secures these ends. Why should not the system so successful in one branch of the government service, be established to secure similar and equally necessary results in the patent office?

(c) The examiners should be relieved from all political influence. Civil service reform has attacked the question of political interference with patent office appointments with little success. The evils from this cause now existing are great, and call loudly for remedy. The army and navy system put those departments of the public service almost entirely beyond the reach of the politicians. Thus it should be with the patent office.

II. The patent office of the United States now occupies a part of the building known as the patent office building, the balance is occupied by other branches of the interior department.

The patent office building was constructed with money paid to the government by patentees—and when first built was large enough for the accommodation of all the departments which now occupy it as they then existed; but as the work of the patent office increased additional force became necessary, until now the officers of the patent office are crowded to an extent that greatly hampers and impedes the transaction of their business. Separate accommodations should be provided for all the occupants of this building except the patent office. The space available would then not be any too large for the growing demands of the office.

III. The acquirement of more space would enable the patent office to secure a much needed addition to the existing facilities, that is to say, a laboratory—where inventions requiring demonstration could be thoroughly tested. The members of the Electric Light Association know how great is this need. No branch of invention is based so entirely upon experiment as the electrical one, and in order to obtain a valuable patent from the department, it is often necessary to set up the apparatus and prove to the examiner by actual test, that what the inventor claims is actually true. This can only be done now at the cost of much time, annoyance and money, and when these are not at the command of the inventor, his application for patent on his invention, often a valuable one, is rejected, when if proper facilities existed in the patent office, he might obtain the just reward of his labor.

IV. When an application for a patent is made by an inventor, the consideration and determination of what rights shall be granted to him, depend; first, upon the statute law, and second, upon the interpretation of that law, by those empowered to grant rights under it, and the rules of practice, established by the statutory authority, setting forth that interpretation for the government of the subordinates, who are of necessity vested with a part of the administrative duty. It is easy to see that unless the interpretations of the statute are uniform and the rules of practice clearly defined and a uniformity exist in the enforcement of those rules, great confusion must exist and great injury result to the rights of patentees.

The rules of practice of the patent office and the decisions of the commissioners of patents are the fundamental law of the department, but great latitude is given and taken by the subordinates. Practically the examiners are the real judges of both law and fact, with reference to the questions that arise in the issuance of patents. These examiners are about two hundred in number, and it is apparent that unless the practice of the patent office and the interpretation of the patent law is clearly settled, this subdivision of jurisdiction must lead to great disparity of ruling by the various examiners. And this in fact is just the state of affairs which exists to-day.

The commissioners of patents are appointed by the President, and are chosen almost invariably for some reason that has no connection with patent law, and in fact it has been many years since a man has held the position of commissioner of patents, who knew anything about the patent law or patent office practice before he took the position; and for some reason the position of commissioner has of late years not been occupied by the same man for more than two years together. So that with the directing head of the patent office, changing on an average every two years, and each time a man taking the position who is almost totally unfamiliar with the subjects which are presented to him for determination and government, it is not surprising that the examiners should be at sea with reference to the law, and the inventor and his solicitor in a hopeless state of uncertainty as to what kind of a patent can be obtained or what rights are granted under it when secured. Two quasi courts exist in the patent office: the board of examiners-in-chief and the examiner of interferences, and from each of these appeals lie to the commissioner of patents. These officers are constantly changing and their rulings are subject to great fluctuation.

It is the universal voice of almost all those who have examined this question, including the commissioners of patents themselves, that a strong permanent court should be established in the patent office, the judges of which should hold office during good behavior, and who should be chosen from among the prominent patent lawyers of the country or promoted from the ranks of the patent office examining corps. In this court should be vested the jurisdiction of the commissioner of patents, the board of examiners-in-chief, and the examiner of interferences. The decisions of this court should be published and would become the law of the patent office. Such a court being permanent and being controlled by its own precedents would soon crystallize the practice into thorough working shape, and embodying in itself the jurisdiction now subdivided among many officers, will ensure a uniformity of decision among the several branches which does not now exist. Such a court would relieve the circuit courts of

the United States of much of the patent litigation now cast upon them. A reference to the report of one of the commissioners will suffice to illustrate our meaning. The following is from the report of commissioner Montgomery of 1887:

"Aside from the burden which this imposes upon the head of this office, there is a want of uniformity in the decisions which emanate from time to time from the respective commissioners of patents, which ought to be corrected. I know of no better way to correct this evil than the establishment of some tribunal to consist of at least three judges, whose tenure of office shall be fixed, and to whom all appeals shall lie. I have no doubt that the establishment of such a tribunal with such jurisdiction would not only make it possible for the commissioner to conduct a more successful administration of his office, but would secure to inventors and to the public a much more intelligent and uniform exposition of the law of patents and of the important questions which now of necessity must be determined so hastily.

"I again invite attention to this subject for the purpose of asserting that my experience of the year last past has not only confirmed me in views which I then expressed, but has made much more manifest to me the necessity for some legislation of this character. A court of sufficient dignity and strength ought to be created, and such tribunal might very properly be invested with final jurisdiction in all matters pertaining to the patentability of an alleged invention as well as all matters of interference between litigating applicants. Such a court with such jurisdiction would not only result in leaving the commissioner free to attend to the other pressing duties of his office, but would inevitably relieve the federal courts of much of the litigation upon these subjects with which they are now burdened."

Mr. Steuart continued as follows: I have thus presented to you some views with reference to the desirable changes and additions to the existing patent laws, which we desire to secure; and I have endeavored to show you the ground upon which are based those views.

I must also make a report of the work of the committee which I have had in hand during the last six months, in attempting to bring about the results which are here outlined to some extent.

At the meeting in Boston, held last August, the association passed a resolution authorizing the legal committee to introduce into Congress a bill providing for the creation of a commission to be appointed by the President of the United States, whose duty it should be to revise the existing patent laws, and report a bill to Congress at its next session providing for such changes as they might think desirable. In pursuance of the preparation of that bill, and in looking over the ground to see whether the course was a desirable one, I was met on every side by the earnest opposition of the ablest and most careful lawyers in the country, those most interested in the patent system, and they came to me with this proposition: They said, "You are doing a good work; you are in a good line; but there is an evil that we cannot escape; there is an opposing force that we must consider, and that is a deep-rooted opposition to the patent system as an element in our national policy that exists in some parts of this land. That opposition is represented upon the floor of Congress by a great many members; and any bill which is introduced of this kind, opening the door wide to revision, may have the effect (and the danger is an imminent one) of giving opportunity to these enemies of the patent system to come in and do it harm." As the result of that advice (and I found the sentiment which prompted it very general) the committee determined to change its course of action, and not to introduce that bill, but to frame another. The question of what that other bill should contain has occupied the mind of the committee up to this time. It has not been fully determined, but it will be very shortly. For the purpose of arriving at a solution of that question, and determining what that bill should contain, and for the purpose of interesting the members of the association in the work of the committee, the committee entered into personal correspondence with every member of the association and also with every person whom they could find who was directly engaged in the electrical business. I think that I do not speak too strongly when I say that they have been corresponding with not less than one thousand people throughout the country, and we have by that means been able to gather a mass of valuable information. The committee published a pamphlet, 2,000 copies of which were distributed among the members of the association, the members of Congress, and among others who were interested in the subject. They have more lately published another pamphlet, 1,000 copies of which have been distributed throughout the country, the purpose of which was to interest those whom we could reach in this subject, and get their minds into such a condition that when we were ready to present the bill we would be prepared to call upon them for their aid. I go from here to-night to Washington for the purpose of making arrangements in your behalf before the committee of patents of the House of Representatives; and I have a memorandum here of several bills which are now pending before the House Committee, which it is our effort to oppose. For the purpose of looking after this question the committee have been partially instrumental in organizing in the city of Washington a bar association among the patent attorneys in Washington. That association embraces the most important men in the profession in that city; and, being on the spot, we look with great confidence to their aid in opposing anything detrimental to the patent system, and in aiding us very materially in promoting our efforts before Congress. When I presented the subject to them I found that they were deeply interested in it, and anxious to join hand in hand with us in attempting to improve the system. The meeting which will be held to-morrow will be attended by a number of gentlemen whom I have notified, from different parts of the country—from Chicago, Boston, New York and Providence—all of whom will come to oppose the passage of certain bills which are now pending before the House. One of them is a bill which provides that patents not used in manufacturing, but held to control trade, shall be vacated by due proceedings and at the instance of anybody who wants to use the inventions. A second measure is an "innocent purchaser" bill (which you are probably all familiar with) which protects a man who cannot be proved to be a fraudulent user. The third bill gives to the circuit courts of the United States the power, at the instance of a would-be user of a patented invention, to examine the patent, and determine what would be a reasonable royalty, for that would-be user to pay for the use of the patent, and to grant to him the privilege of using it without any restraint on the part of the owner. A fourth bill reduces the term of an United States patent from 17 to 7 years. There are two other "innocent purchaser" bills, and two others which touch the issue which is now troubling telephone companies, and which may some day trouble you in your electric light business,—and that is the interference of state legislatures with the right of the patentee or the owner of a patent, to control the use of it. In Indiana, the legislature has passed, as you are all probably aware, a law which limits the price which shall be paid by its citizens for the use of the telephone. That law has resulted, in many cases, in the refusal on the part of the company to permit telephones to be used at all, except on their own terms. This bill is now introduced (there are two of them) for the purpose of enabling the state legislatures to bind the owners of patents by such legislation.

All of these questions are vital questions, and they are questions which lay at the very root of the patent system. If any of these bills become laws the system will receive a very serious blow; and it is our duty in your interest to oppose their passage. At the same time that the House committee convenes to-morrow there will be a meeting for the purpose of opposing the passage of these bills, and there will be a number of gentlemen in Washington, many of whom represent the electric light interests,—the Edison company having promised to send their counsel, the Consolidated company will send theirs, and the Westinghouse companies will send theirs; and we will have gentlemen from various parts of the country all of whom are deeply interested in this question and in the effort to reform our patent laws.

As I have said, we will hold a convention in Washington to-morrow to discuss the question of exactly what is desirable, and in what particular direction we shall move. We are all of us very well satisfied that our best chance of success lies in attempting very little,—in narrowing our efforts down to one or two salient points, and concentrating upon those. The probability is that we will limit our efforts to two points only: One, will be an increase of the salary of the commissioner of patents, to such a sum as will justify a man of sufficient capacity in holding the position long enough to be able to establish some satisfactory and uniform practice in the patent office. Figures were given me the other day—I did not make the calculation,—but gentlemen of eminence in Washington who have been familiar with the office for many years, have said to me that they made the calculation, —and that the result is, that for 14 years the average time of the commissioner of patents has been but 13 months. When you consider that each one of those men has entered office with comparatively no familiarity with either the laws or the practice of the office —with some few exceptions—you can understand how perfectly chaotic must be the condition of the rulings and practice of the patent office. That will probably be one of the points upon which we will centre. A second will be to establish an intermediate court of patents, which will hear appeals from the circuit courts, and also from the patent office. This is the work which the committee now have before them.

Mr. Mason—It strikes me that it would be well to reinforce ourselves by an effort to gain the co-operation of the various societies of engineers and manufacturers, who are, if not equally interested with us, at least have a considerable interest in this subject; and who would probably be glad of an opportunity to join in our efforts.

Mr. Leggett—I dislike to arise in opposition to a measure of this character, but from the very outset of this action on the part of this association, it has struck me as a measure of doubtful expediency—a thing which we ought in a very quiet way to abandon. Now, these questions, every one of which were raised by Mr. Steuart in his report, are questions which affect not electric light companies, but the manufacturers of electrical apparatus. There is scarcely a manufacturer in the country who is not willing and anxious, perhaps, to change certain features of the

patent law; and yet I doubt very much, whether they desire the system to be attacked in a general way. We have a patent system which is by far the best in the world. There is no question about that. Canada has followed it, and has made a patent law almost identical with ours. England has followed, and has patterned almost word for word the principal sections of our patent law. Germany has followed within the last three or four years, with a new patent law based almost word for word upon ours. The result of the patent law of this country has been the development of industries of such great magnitude that it has been copied in the laws of all nations. It therefore seems to me very bad policy at this time, when there is agitation against certain features of the patent law to raise the issues which are now suggested. Many of you will recollect the action which was had a few years ago, on what was termed Bill 300; at that time, a bar association was formed in the city of Washington with a view of dealing with this matter, and I think it was never formally disbanded. That association it is safe to say, together with its ramifications throughout the country was able to collect and expend probably $100,000 in an effort to amend the patent laws. Every feature which is here raised was raised at that time, I think. The bill went into the House and into the Senate, but there was no possibility of getting it through.

This is a matter which affects the manufacturing interests solely, and not our association. It is a matter in which a hundred thousand dollars was expended not later than 1877 and 1878 in a futile attempt to amend special features of the patent law,—it seems to me in such a matter that it would be poor policy for this association, where not one single interest is involved, to go ahead and expend the little money that we have on hand to seek to carry out measures of this character. I do not believe the move reflects the sentiments of the different interests of this association.

Mr. Steuart—Mr. Leggett suggests that we are engaging in an effort to tear down the wall of protection to patentees. I am sorry if I have expressed myself so obscurely. I am sorry if I have not made my meaning clear in my effort to suggest that the whole purpose of this committee, the whole purpose of the effort which has been made, has been to build up around the patentee every safeguard and every weapon of defense against infringers that could possibly be devised. That has been our purpose solely. Referring to Mr. Leggett's suggestion as to the advantages which our system has over other systems, I wish to say that I fully appreciate them. We have got the best system in the world. and those countries that have followed us,—Germany, England and Canada,—particularly Germany, which has followed us most closely, have carried our system to the very point beyond us to which we want now to carry it. The last thing done by the German government in perfecting their patent system has been to establish a court specially for patent appeals, and to put over their patent office a man who will hold his position during a long term of years, sufficient to enable him to understand the practice and to dictate proper rules to the examiners who are under him. That is what we seek. That is all that we are now seeking. It is simply to carry forward our system so as to complete it. and put it where our imitators have already gotten theirs. With reference to the effort which was made 10 years ago to alter or amend the patent system, Mr. Leggett has suggested that an effort was made in which a hundred thousand dollars was spent, and which was unsuccessful because, as he intimated, it was impossible to make any changes. I would like to read a clause from a letter which I have in my hand from Mr. James J. Storrow, whom we all know, of the Bell Telephone Company, on that subject. He says:

"Ten years ago an attack was made upon the patent system, as you know, by an organized company of infringers. The best that my associates and I, representing a large amount of patent property and interests, could accomplish, was to agree to some modifications which we thought were wise, and would tend to remove some features of the law which we had to admit, however, were very obnoxious, and to agree in a modified form to some others that we thought would have passed in a worse form if we did not come to an agreement about them."

The facts with regard to that effort were, that it was an effort by a band of infringers who were determined to break down the patent system if they could, or to introduce features into it which would enable them to use certain patented property which they wanted to use, free of charge, and free of liability for infringement. A hundred thousand dollars was spent, but it was spent to a large degree in defense of the patent system against the attack of the infringers. At present we propose, although there are many suggestions made, but those suggestions are made for the purpose of gaining light upon what is the most desirable thing to do,—at present we propose, and have settled down to the conclusion, as I have suggested that we will do just what Germany has done; we will put over our patent office, if it can be done, a man who is thoroughly capable of managing it, and we will put an intermediate special court of patent appeals, with jurisdiction to hear the technical questions which now go into our courts where there is, in many cases at least, an entire absence of technical knowledge. We are attempting to build around the patent system and around the patentee a wall which will be a benefit to every member of this association. Indeed, I can hardly conceive how any association that has existed in this land could be more interested in the subject, or could more properly be said to be the right source whence efforts of this sort should spring than this association.

Mr. Geo. M. Phelps, Jr.—I share with Mr. Steuart his surprise that the work of this committee, or any action of the association upon it, should be regarded as in anywise an attack upon the patent system. I suppose it is quite within the truth to say that the movement was conceived and started purely with the purpose of conserving all the protection that inventors now have, and of clearing up as far as possible the obscurities that exist in relation to inventors' rights, by better methods applied to certain portions of the system as now practised. I think there can be no doubt about that. I was also a good deal surprised that any one should fail to see the very immediate and direct interest that all the members of this association, as well as manufacturers, have in this question. It seems to me that the confusion which exists in respect to the relations of many patents to one another, and consequently to the rights of various people in relation to one another, is a source of constant anxiety to nearly every one engaged in the electric light business. It would seem that the work of this committee has been fully justified, and the time spent upon it well accounted for by the results that have been reached up to this time. If I understand our position now we are expected to pass upon the suggestions made by the committee, for I suppose that the remarks of Mr. Steuart made after reading the report of the committee as presented in the printed pamphlet, are to be considered also as the report. The proposition as I understand it is to abandon entirely the idea of the creation of a commission, and instead of that to direct the energies of the bar association of Washington, supported by an expression of opinion as evidenced by a vote of this association, towards the accomplishment of two distinct measures: the creation of an appellate court, and the increase of the salary of the commissioner of patents. Both of those measures seem to be quite free from the objections which would attach to any proposal which in terms by implication should seem to have for its object an increase in the scope of protection to the patentees. I am very glad that the committee, and probably all the members of the association, or a large portion of them, have recognized the danger of introducing any measure for a general revision, or any which should seem obviously to be addressed to the increasing of the value of patent monopolies in a money sense. The present plan simply looks to conserving the rights and the protection now afforded by our patent system, by a modification of the methods of administering the patent laws. The measures suggested, as they seem to me, do not afford an obvious opportunity for attacks upon the patent system, and it would be difficult to offer amendments to either of those propositions germane to their subject-matter which could successfully attack the patent laws. Therefore, I hope the association will see fit to endorse the proposition of the committee as I now understand it to be.

Mr. Leggett: I think I may be misunderstood if it is assumed that I assume that the action of this committee is in the nature of an attack upon the patent system. I do not so regard it. I think that the recommendations of the committee, in most respects, are good, and that they will correct abuses in the particular channels indicated. The point with me is simply this: Is it good policy for this association to divert its funds (which are very limited) in order to carry it into another channel foreign to its objects?

The President—Up to the present time the money expended by the legal committee has not been taken from the funds of the association, but has been contributed through voluntary subscription by the representatives of different interests; and there is now remaining of that special fund about $250.

After some further discussion by Mr. Garratt and Mr. De Camp, chiefly touching the question of expense to the association, the President asked Vice-president Weeks to take the chair, and took the floor.

Mr. Morrison—I do not discuss the legal phases of this question, nor any of those outlying ramifications which have been discussed by some of the gentlemen who have spoken. I wish to call attention to the point, which has not been adequately presented, that the men who are using electric light patents, the men who have paid their money for these patents, have found them, in a great many instances absolutely worthless. Now, there were patents and there are patents; and while Mr. Leggett has held up to you the wonderful success of the Bell Telephone, which I believe has had more piratical attack upon it because of its success than any other patent ever obtained in this country, while he has held up this thing, he has brought in collaterally the protection which has been afforded to our business. Now, I maintain that a proper system in the patent office (and I want you to think this over) would make a patent issued from that office just as good as gold,—if the system were right and if proper safeguards were thrown about it. I want also to make this statement, that, throughout this broad land where millions

of dollars have been invested in the electric lighting business, there have been very few, if any, favorable decisions in the courts in electric light patent suits. The result of that has been —what? It has been that the promoters of electric light companies go into various communities in which they live and persuade their fellow citizens to put their money into an electric light company. When you deal with a parent company its representatives will say to you, "We have the foundation patents; we have property here; we are not offering you a paper upon which is written down a number of set phrases and words; but we are offering to you something which is just as good as gold, because we are going to take your gold for it." But what has been the history of such enterprises? I do not want to reflect upon any representatives of parent companies who are here; but the melancholy fact stares us in the face—melancholy to those who have put their money into electric lighting companies and have got no return from it,—that infringers came into your territory and established themselves cheek by jowl with you; and the result was that you found yourself in a few months doing business for nothing, and a promised decision in court was never delivered. Decisions are seldom if ever reached in electric light patent suits. Therefore, the purchaser of the patent and invention suffers. The parent company, with much gilt-edged work thrown about the business, sells you what? It sells you these patents. Why do you buy them? You think that you are investing in a property which will bring you a good return for your investment. But what do you find? You find that there is no punishment for the so-called infringers. You find that your patents are comparatively worthless. Why is this? Surely the investor believes and has faith in his invention; surely the men who make these representations to you are in earnest; they are honest; and they believe what they tell you. But that which they tell you is not true. The stern fact is bitter experience, which has buried electric light company after electric light company. They have gone down in financial ruin, leaving tombstones all along the road shewing where the contents of men's pocketbooks have been scattered. Where is the fault? If the fault is not with the men who have urged you to buy their wares, it must be in the patent office. These are the conclusions which I come to. These are not the conclusions of the lawyer; but they are the conclusions of those who have lost their money, sinking it in these speculations—that is the word—speculations, when they thought they were engaged in a fixed and substantial business; it is the conclusion of these gentlemen who have invested and lost their money,—that there is something wrong in the patent office. I am not speaking for men who possess a patent incubator, or for the man who has a patent plow, or a patent harrow, or a patent washing machine, or a patent cider press, because I permit to each of them the same liberty of speech and action which I ask for this association and for its members individually; but I say that what we want to do is to protect our own interest as far as lies in our power, and we cannot protect them by sitting idly by. We must act. The paltry dole that you spend in aiding this legal committee,—whether it be $250 or $5,000, would be money well spent if it only succeed in bringing before Congress a discussion of this thing, so as to lay bare the impositions which have been laid upon inventors and investors, and the frauds which have been perpetrated upon men who have invested their money in patents.

After further remarks by Mr. Leggett, Mr. Foote, Mr. Duncan, Mr. Garratt, Dr. Moses, Mr. De Camp, and others, the subject was disposed of by the passage of a resolution, offered by Mr. Duncan, as follows:

"That the report of the legal committee be approved, and the committee continued without expense to the association."

Dr. Moses—We have the pleasure of having with us to-day a gentleman of distinction in electrical matters, Professor E. L. Nichols, the successor of Professor Anthony at Cornell University. I hope that the privileges of the floor will be extended to him; and I would also suggest and move that we request him to allow his name to be added to the committee on insulation, in order that we may obtain the advantages of such a laboratory as that of Cornell University. I would also suggest that the name of Mr. E. G. Acheson, a gentleman whose name has been brought prominently before the electric world recently as the inventor of a very beautiful heat transformer, be added to that committee.

Professor Nichols was elected to be an honorary member, and then by vote of the association both he and Mr. Acheson were added to the committee on insulation.

Mr. Duncan—The committee on annual dues offer a substitute for Article VIII. of the constitution. The present article reads as follows:

"The membership fee of each member shall be $10—which shall accompany the application.

"The annual dues shall be $10—payable in advance, and shall cover the calendar year."

Your committee are unanimous in recommending the striking out from that article of all requirement as to an initiation fee, and making the article read as follows:

"The annual dues shall be $20, payable in advance, and shall cover the calendar year."

In making this recommendation the committee had in view the increased expenditures of the association. A careful estimate of the cost of printing the proceedings of each session indicates that it will be about $400. For two meetings a year the cost of printing alone will be about $300, and the expenses of the two meetings for various incidental purposes amount, as near as we can estimate, to, say, $800. Therefore, we have, outside of any salary to the secretary or treasurer, a necessary expenditure of about $1600 per year. In discussing the financial condition of the association the executive committee arrived at the conclusion that the interests of the association require the continual services of a secretary and treasurer in procuring new members, in carrying out the orders of the executive committee, in preparing papers for the meetings, and generally giving more attention to the duties of secretary and treasurer than heretofore. There is no reflection intended upon the present or former secretary, who, while the association has not been able to pay them a proper salary, could not be expected to give their whole time and attention to its affairs. We estimate that in addition to this sum already stated, viz., $1,600, we should have a paid secretary and treasurer under the direction of the executive committee, at a salary of at least $1,000 or $1,200 a year. Therefore the total expenses of the association will amount, as nearly as we can calculate, to between $2,600 and $3,000 per year. We have now 178 members in good standing. An assessment of $20 per year will bring us a revenue of $3,560.

The amendment was unanimously agreed to.

Dr. Moses here rose to a question of privilege, calling attention to Mr. Acheson's connection with wire and cable business as a possible objection in the minds of some members to his serving on the insulation committee. Dr. Moses, as the proposer of Mr. Acheson's name, thought an opportunity for reconsideration should be afforded.

After remarks by the President and several members, expressing confidence in Mr. Acheson's qualifications, his retention on the insulation committee was unanimously agreed to.

Mr. Chas. A. Schieren then read a paper on "Leather Belting." (See page 112.)

Mr. H. W. Pope—I would like to ask Mr. Schieren about the wearing of the edges.

Mr. Schieren—The first belt which I made up about six years ago is still running. Before I came to this convention I took it down and had it taken apart. The belt is 28 feet 7 inches long, and it had stretched nine inches in the first three months. After that there was no further stretching. We took the belt down, examined it closely, and found no elongation whatever. It is 3½ inches wide, one inch thick, and transmits 15 h. p., under the following conditions: It connects two 38 inch pulleys, and the pulleys run at the rate of 125 revolutions.

Mr. Pope—I would like to ask what has been the experience in Europe with these belts?

Mr. Schieren—My attention was drawn to these belts while in Europe some ten years ago. I looked into the matter and thought very little of them. About six years ago I went to Europe again and looked at them and thought better of them. I thought there was something in such belts that would fill a gap in this country, and I determined there and then that I would try them here. However, other matters came up, and I did not try them until three years afterwards. In reference to the experience in Europe I will state that two years ago I was there and met several electricians, and got from them some very valuable information with regard to the use of linked belting in running dynamos. Their dynamos there are run much slower than yours here. A great many of them favor linked belts. They only use one pin there, and engineers told me that it takes four months before the pin adjusts itself to the rounding of the pulley. On the whole, they speak of them very favorably.

Mr. Pope—Another query suggests itself, and that is whether in the alternating system—running at 1,6(0 revolutions—the link belt would be preferable, or as good as others?

Mr. Schieren—A gentleman called on me and said: "Your linked belting has attracted my attention, and I would like to receive some information about it. My company would like a belt which would run a mile and a half per minute; can you make such a belt." I said that I would try to do it. I did; and I was successful. The belt worked successfully. I made it out of very light material. The belt is to-day running at the rate of a mile and a half per minute. I suppose that that is the kind of belt that Mr. Pope refers to.

Mr. F. Ridlon: I have used one of these belts, three and a half feet wide at a speed of 2,000 feet per minute. The only fault I can find with it is the stretching.

Mr. Rice—I would like to ask Mr. Schieren about the amount of power consumed by this belt as compared with ordinary belting. Does the belt itself use more or less power—I mean, for the bedding of the belt over the pulley?

Mr. Schieren—My experience in linked belting has been this, that it will transmit under certain circumstances more power than the ordinary belt. It will do it every time. In some instances we have put on an eight-inch belt and have taken off a twelve-inch belt. In some instances we have put on a twelve-

inch link belt, and have taken off a ten-inch belt; and it would not drive with a ten-inch belt owing to the difference in circumstances. So to-day I may say that we are ignorant in regard to the amount of power comparatively that they will transmit. We are constantly making experiments and improvements, and are gathering valuable information in that way, but I am sorry to say that I cannot answer your question intelligently.

Mr. Law—I would like to ask Mr. Schieren if he has had any experience, or enough experience, to determine the amount of damage that oil does to this belt, as compared with ordinary double belting. In some dynamos the belt is saturated with a large amount of oil?

Mr. Schieren—So far no claim is made in that direction. Of course you will understand that if the leather lies on the edge it exposes its fibre more than otherwise. Leather is a great absorber. I use blotters of leather in my office, because leather absorbs a fluid at once. No doubt you have noticed this on running your dynamos. It absorbs oil very fast. I think that the link belt would absorb oil more than other belts do, but that could be obviated by using a dressing which would close the pores of the exposed part of the belt.

Mr. Law—What sort of success have you had with almost perfectly perpendicular belts?

Mr. Schieren—We have had very good success. The only trouble with perpendicular belts is this—at first these link belts stretch considerably.

Mr. Jesse M. Smith—One of our greatest sources of loss of power in fast running belts—that is, in belts running 5,000 or 6,000 feet per minute—is the imprisonment of air between the belt and the pulley. It amounts to carrying the belt away from contact with the pulley; amounting sometimes to a quarter of a revolution, or a quarter of the circumference of the pulley. Experiments have been made that prove that a belt will drive more power if holes are punched through it, when run at high speed. The link belt which Mr. Schieren has spoken of, has, of course, a large number of holes through it. For that reason it is very easy for the air to escape and thus permit a much closer contact. I think it is a fact, and that it has already been proven in a great many cases that a linked belt will transmit more power for the same width than an ordinary flat belt will.

Mr. T. C. Smith—I can say, in answer to Mr. Rice's inquiry as to the bending strain of belts, that, without having made any particular examination of it, any one who has looked at an ordinary belt running at a high rate of speed will notice that the speed of the belt is not sufficient to overcome its stiffness and make it hug the pulley closely; but a linked belt will in all cases lie right on the pulley and form a true tangent to the periphery of the pulley wherever it strikes it. The flexibility of the belt is so much greater than that of an ordinary belt that the bending strain is less. With regard to vertical belts I will say that we had a belt of that kind, running 7,500 feet per minute, and we found that a link belt while running at that tremendous velocity would carry more power sticking closer to the driving pulley. In one case we used an ordinary eight-inch belt and then we tried a link belt, and it did the work admirably, but we had to abandon it for a very curious reason, and that was that when running the link belt at such a high rate of speed it caused the belt, in coming down on the pulley to make such a terrific roar that it made the engineer sick—it gave him a nervous headache. It was due perhaps to the fact that our station was only six feet from the floor to the roof, and with the 300 h. p. dynamo in a room only 20x30 the noise was prodigious. But so far as the belt itself was concerned its work was satisfactory.

The association here took a recess until three o'clock P. M.

WEDNESDAY AFTERNOON SESSION.

E. R. Weeks, vice-president in the chair.

Mr. Ridlon offered the following resolution:

Resolved that Article IV. of the constitution be hereby amended to read as follows:

The president and vice-president shall be elected by ballot to serve during the following meeting. The treasurer and secretary, who may be one and the same person, shall be nominated by the president, subject to the approval of the executive committee. The executive committee shall be chosen by ballot at each meeting, either annual, semi-annual or special, to hold office from the close of the meeting at which they are elected until the end of the meeting at which their successors are chosen.

On motion of Mr. Morrison, the resolution was laid over and made a special order for Thursday morning.

Dr. Liebig then read a paper on "Electric Motors." (See page 105.) After the reading of the paper the chairman called upon Mr. A. Reckenzaun for his views upon the subject.

Mr. Reckenzaun considered the paper of much interest to men who are fond of mathematical problems, but he thought that members of the National Electric Light Association have little time and less inclination to devote themselves to purely theoretical investigations. The formulæ given by Dr. Liebig are too complicated for practical use, and they involve numerous constants which can only be determined by costly experiments. Such formulæ may be very useful for comparing the relative merits of different machines after the same have been constructed and tested, but for the purpose of designing motors or dynamos we require simpler and more practical methods. Mr. Reckenzaun preferred the reasoning first expounded by Gisbert Kapp, and originally published in *The Electrician*, of London, a few years ago; the speaker explained the methods by the aid of simple formulæ and sketches upon the blackboard, and referred the audience to Kapp's book "On the Electrical Transmission of Energy," for detailed description.

Mr. H. McI. Harding—Coming to certain practical points, we want to know how much money we can make by selling electric power. Now possibly a few figures which are the reports from about 80 stations which are now selling the electric current for power may be of interest It is impossible to fix a price for any motor of any given size. That is to say, you cannot take a five h. p. motor and charge $500 a year, That, you will see a little later, is not possible. All of you in trying to sell electric power have met that difficulty. The first thing to do is to divide all the classes of industries you intend to supply, say, into two or three classes: First, constant use. If you are running a ventilating plant and charge about $120 for one h. p., that is constant use. You take next such things as printing offices and machine shops—all work of that kind, which we call partially intermittent. In that case the price has been established—and it would be well, I think, to have a price throughout the country in order to settle difficulties as to what the price of power should be, because the company seems to think that the one who is selling the motor wishes to have a very low price, and the one who is selling the motor thinks the company wants more than it is worth. First, be sure to sell the machine to the customer. Where motors have been rented the result has not been satisfactory. It has been tried by gas companies. Steam companies have tried renting steam engines, but the engines are never cared for and are in wretched condition, and the same will be true of electric motors, and the repairs of the machines after they have been run for a long time—not oiled and neglected—will more than eat up the profits. Take a half horse-power motor; the average price seems to be $75 a year. Of course that is 10 hours' service. That would be equivalent to about two cents a day, which for sewing machines is not high. One horse, $120; two horse, $200; three horse, $270; five horse, $425; seven and a half h. p., $600; 10 h. p., $750, and 15 h. p. and up, about $70 per horse-power per year. If you sell 15 h. p. at $70 a year, the intermittent use will show a large profit. These data we have obtained in this way. On every machine running on the constant potential circuit of the Edison company in New York—also in other places—they put a meter and they examine the meter at the end of each month, and that data has been of great value, because we know exactly how much the customer is using. Take the third class, which is the elevator work, you will find that to be a very profitable source of income. In elevator work for a five h. p. motor you charge $300 a year; for a seven and a half h. p. motor $360. You can charge say, about $400 for a 10 h. p. Suppose a man puts in a motor of five h. p. for a small freight elevator—if, however, he has a very large platform he can use 10 h. p. once to take up a load—you will find he is not using so much current. Now from actual tests they have found in New York that on a freight elevator charging at lamp rates, which is one and one-fifth cents for six c. p. per hour. That is equivalent to $312 per h. p. per year. The actual amount used very seldom exceeds $150 a year, which shows a very handsome profit indeed. If you calculate that you are selling your power at the same rates as you are selling the lights, then if you can make 10 per cent. by selling your current for four hours per day, if you can sell current for 10 hours a day you are making two and a half times as much, or 25 per cent. possibly. These figures may help some of you in establishing the rates which you shall charge for power. [Applause.]

Mr. Wm. Lee Church then read a paper on "Independent Engines for Incandescent Stations," followed by Mr. J. B. Edson with a paper on "The Economic Value of Steam Pressure Records."

Dr. Moses—I would like to ask Mr. Church what is about the average size of independent engine that he would recommend.

Mr. Church—The question is not governed by the size of the engine. It is governed by the size of the dynamo, and that in turn is governed by the nature of the circuit which has to be laid out. You have got to discover what your distribution of light is to be, then adapt your dynamos to that; then adapt your engine to the dynamos. Without professing to have any knowledge whatever of the economies of station management, it seems to me that a large station will naturally run in the direction of uniform sizes of dynamos throughout, for the one reason that that involves simply the carrying of one line of spare parts, and more ready interchangeability. Of course, in a station in which the light fluctuates as much as in this that I show, the smallest dynamo should be adapted to the minimum load that obtains over the greatest length of time. But I should determine as far as possible what my minimum load was to be, make that my smallest unit, and after that bring all the subsequent units to the same power, or, if found better, to still larger units, as indicated here.

Mr. T. C. Smith—Mr. Church's paper is limited to incandes-

cent stations. The use of a small engine in arc stations has been very often condemned. In an arc station you know about what your light is going to be. If you know your load is going to be 500 h. p. you can stop your engine at pretty nearly its full load. There the big engine is undoubtedly the more economical. But in an incandescent station there is no regulation as to the amount of load. We must keep that point clearly before us—that this discussion is limited exclusively to incandescent work. There are comparatively few incandescent stations that are running with shafting. Most of them are running with independent engines.

Mr. W. C. Kerr—I wish to draw attention to a point that has been called to the attention of the association every time a power discussion has arisen, and I do not see the need of mentioning it again except for the fact that there seems to be a confusion between the questions of large *versus* small engines, and subdivided *versus* non-subdivided power, less a question of size than of subdivision.

Mr. J. M. Smith—Mr. Church spoke about the economy of small engines as compared with large ones. He is perfectly right in that. But I think that the question might be carried a little bit farther. The high speed engines, as a rule, are not as economical in coal as the larger engines, for the reason that we cannot get as perfect expansion; we cannot get as good compression lines on a single valve automatic engine as we can on an engine with four valves, as in the Corliss type. But there is another means of getting at that economy which is due to high expansion, and that is in compounding. It is known that all the ocean steamers now are run on triple compounds; that is, the steam is taken at high pressure in one cylinder and expanded into the second cylinder and from the second into the third, and the very highest economy that has yet been gained has been attained with those engines. Now the same thing can be done with the high speed automatic engines which we are now using for electric lighting, and with very great economy; and the tendency, I think, which has already started in Europe is coming to this country and we will very shortly have economical high speed and constant regulating in the engines for direct running of dynamos. I understand that several of the prominent engine builders are now bringing out compound engines for high speeds, and I think the economy that has been talked about for the large slow speed engines will be met in that particular very shortly.

Mr. J. M. Smith, Mr. Kerr and Mr. Rice here spoke further upon several features of the subject.

Mr. Church—I said that the smallest unit of power should be adapted to the lightest load. I think there is but one way to settle the question as to which method is the most economical, and that is not from theoretical conditions, but from the results of those stations which operate the two systems, and extend it into the cost of the various items per lamp hour. That will settle it. Every well managed station has its nightly report sheet. Extend the one item of coal alone out to its course per lamp hour. That will give the relative coal economy; but that is not enough. Then you must extend the collateral items of repairs and all these various items extended out per lamp hour, and then you can combine them and ascertain what the grand total is as to the question of direct or countershafted engines. Anything short of that is argument and not demonstration.

Mr. A. P. Wright—I have recently taken charge of a station in New England where we are using large engines with countershafting. We are using somewhere near five and one-fifth pounds of coal per horse-power per hour, which I attribute in a great measure to our want of subdivided power. Of course there we have an extreme case. But it will not be an extreme case in the future. On Saturday night only do we have an ampere line that approaches anywhere near Mr. Church's illustration. On the ordinary week days our stores close at 6 o'clock, so that our highest ampere line is maintained for a short time only, and then very rapidly falls.

Mr. T. C. Smith—Has any one noticed this peculiarity of our service in Pittsburgh? If it is dark for an hour in the morning, between 9 and 10 o'clock, our ampere curve will jump away up. No matter how bright the day becomes after that, it does not drop much.

Mr. Kerr—Mr. Church's paper mentioned the difficulty of running incandescent lamps from very slow speed engines on account of the fluctuation from revolution to revolution. That is a thing which can be observed in a great many places. Another point is closely related to that. It is well known that a slow speed engine has comparatively small friction. If I now put fly-wheel enough on a slow speed engine to prevent the flickering of the lamps you will find that it has a very large friction. The reason that a slow speed engine has small friction is because it has not fly-wheel enough, and the number of tons of fly-wheel to give it good regulation makes it a high friction engine. This point is very little thought of in electric lighting, till too late, when a change of fly-wheels has to be made.

Mr. S. E. Barton here read his paper on "The Relation of Electric Lighting to Fire Insurance." (see page 95), and was followed by Mr. G. W. Parker, with a paper on "What Constitutes a Good Carbon Point." (see page 111).

Owing to the lateness of the hour discussion of these papers was deferred, and the session was adjourned till Thursday.

THURSDAY MORNING SESSION, FEBRUARY 23.

The secretary read the following proposed amendment to the constitution.

Resolved, that Article IV. of the constitution be hereby amended to read as follows:

"The president and vice-presidents shall be elected by ballot to serve during the following meeting.

"The treasurer and secretary, who may be one and the same person, shall be nominated by the president subject to the approval of the executive committee.

"The executive committee shall be chosen by ballot at each meeting, either annual, semi-annual or special, to hold office from the close of the meeting at which they are elected until the end of the meeting at which their successors are chosen."

The proposed amendment was discussed at some length by Mr. Ridlon, Mr. Morrison, Mr. Leggett, Mr. Mason, Mr. Weeks, Mr. DeCamp and Mr. Phelps, and was, under a ruling of the President, referred to a committee to be reported upon at a later session of the meeting. The President appointed as such committee, Mr. Leggett, Mr. Weeks and Mr. Duncan.

Mr. T. C. Smith—I have much pleasure in announcing to the members of the convention that we have made an arrangement with the officers of the Philadelphia Gas Co., through Mr. Westinghouse, to have their stand-pipe at 36th street lighted at seven o'clock this evening; and members who have not seen it will find it of interest. I may say that it is equivalent to the lighting of one of the gas wells. For those who wish to visit it cars will be in waiting at this hotel at 6.30.

Dr. Moses—It is perhaps out of order, but just suspend your judgment for a while to enable me to offer a recommendation to the committees that have been appointed by the Chair. A committee is supposed to express the feeling of the body from which they are severed for the time. It is a concentration of action for the purpose of subsequent general discussion. I would therefore ask these gentlemen of the committee who have been appointed to consider the amendment of Mr. Leggett, to bear in mind that we have been going along successfully since the founding of this association under one leadership. (Applause.) If we have been successful it is very largely due to his discretion, and to his continuous government of this body. He now finds the burden a little irksome. But, we may still want him as a wheel horse; there is no telling. Therefore, I would ask that committee to please consider seriously, whether it is advisable in any way to hamper by precluding our re-election of such a man when the time may come that it shall seem desirable. Circumstances may arise in which it may be necessary or desirable for us to have the leadership of one president continued. Therefore, I think it would be wise to consider very carefully whether we should hamper ourselves at any time when we get a good man in office.

I am requested, Mr. President, by E. G. Acheson, the gentleman who was elected yesterday a member of the committee on insulation, to express his thanks to the convention for the honor done him, and to say that while he is perfectly willing to give us the benefit of his experience in such matters, still the fact of his occupying a position on that committee might be misinterpreted by other gentlemen who are connected like himself with wire interests, and therefore, while thanking the association for its action, he respectfully declines the appointment.

The President—Ordinarily the appointment of a gentleman upon any committee would be directly in the hands of the President; and the necessity for a resignation would not exist. Mr. Acheson was paid the high compliment of having been elected to a place on this committee by the direct and unanimous vote of this association; and that is a compliment which was never before paid to any gentleman in the history of the association. It is with the deepest regret (you will excuse me for speaking from the chair, that was one of the rights I reserved to myself when you made me president in Chicago) that I find that the association is now about to lose the services of a man so eminently capable of acting on that committee, and of giving intelligent and useful assistance to this association. I hope, although he leaves the committee, he will not deprive us of those services which he is so eminently fitted to give.

Mr. Acheson's resignation was accepted.

Here followed a group of papers, which, by previous arrangement announced by the President were to be discussed together.

The papers were the following:

"The Distribution of Electricity by Alternate Currents," by Mr. T. Carpenter Smith. (See page 103.)

"The Energy of Alternating Currents," by Mr. O. B. Shallenberger. (See page 101.)

"The Undergrounding of Electric Arc Light Wires," by Mr. W. W. Leggett." (See page 91.)

"Underground Conductors for Electric Currents," by Mr. Jesse M. Smith. (See page 94.)

DISCUSSION.

The President—The four papers are now before the association

for discussion. I would suggest that the first pair be now considered—the practical side of the alternating current system.

Dr. Moses—I have the pleasure of announcing to the convention that we have with us one of the most distinguished electricians of England, Professor George Forbes, to whom the courtesies of our associations have already been extended. I hope that he will give us his views in the discussion of these various papers

The President—The convention will be pleased to hear from Professor Forbes.

Professor Forbes—While I appreciate the honor you give me, I feel that on the particular points which have been raised at the present session there is not a great deal that I can say which would enlighten the people in America as to what has been done in Europe. At every step as I go through your different cities I see how enormously ahead you are over us in England. In large part, papers which have been read have referred to the question of insulation, and as to the laying of overhead and underground conductors. Our experience in England, of course, as to underground conductors is absolutely nothing almost, for the simple reason that our people will not allow us to put our conductors underground. The public in England have a strong feeling that there ought not to be any overhead conductors; they would not allow wires on poles as you have them here—which is a very cheap and convenient method; and our telephone wires have hitherto been carried from roof top to roof top—standards being erected on the roofs; and there is a general feeling among the public that electric light wires ought not to be overhead and ought to be underground. An electric light company also feel that they would prefer to put their wires underground. The opinion seems to be different over there to what it is here. The idea in England is not so much to make a small outlay at the start, as it is to make an efficient system—a system which it will be economical to work afterwards. It is the general opinion of a great number of companies that the best arrangement could be got by underground work. However, Mr. Chamberlain, in 1883, thought it wise to practically prohibit electric light companies from putting their wires underground. The consequence was that for several years after that it was absolutely impossible to start a central lighting station. At the present moment the demand for light from central stations in England has become so great that the companies who are capable of doing the work are determined that they will satisfy the public demand; and the consequence is now that at the present moment central stations are being started in London and in other towns, but always on overhead systems. That is what the government has driven the electric light people in England to. I may mention that the insulation which is used in electric lighting overhead work in England for the alternating current, where 2,000 volts are used, is very superior to what you are using over here. The best possible insulation, of India-rubber and tape of several servings, is being used in the central station lighting which is done on a large scale there, viz., from the Grosvenor Gallery in London. I have always thought that that was very wise; but I must say that from inquiries here among those who have been using alternating currents of high potential I find that a less expensive wire is certainly doing admirably, and I think it is just possible that we have perhaps overdone the matter in England in the way I speak of.

I cannot speak upon the subject of Mr. Carpenter Smith's paper on the alternating system here. It is a most valuable paper, and one from which I myself have learned a great deal, and have taken numerous notes for our benefit on the other side of the water. With regard to Mr. Shallenberger's very interesting paper, I may say that I think those experiments which he has described are very beautiful indeed. I have been lately much occupied with the theory of alternating currents. The chief point which he has brought before us is this,—that you must not try to get at the work which is being done on an alternating current circuit simply by multiplying the volts by the current; because there is a difference between the available current and that implied by the expressed electromotive force. As matter of fact the formula comes out very simply indeed,—that the true work is really the product of the electromotive force multiplied by the line current. That is, the electromotive force as measured by the voltmeter multiplied by the co-sine of the difference of phase between the current and the electromotive force. It is a very simple thing, and it will be easy to get at the figures which give you the value of the co-sine of that angle pretty easily; but it involves a little mathematical work, and this is hardly the place for that. I have communicated this formula to the Society of Telegraph Engineers in London, since my departure from London; and it will probably come to those who are interested in applying the formula to practical work.

I do not think that there is any point on which I can give information here; but I shall listen with great interest to the discussion. Since the subject of alternating currents has been brought up I wish that somebody had given us a little information about a question which has been occupying my attention so much during the last year in connection with alternating currents—the question of meters. I would like to hear what has been done in the matter of meters for alternating currents; because it strikes me there lies one of the chief difficulties in the practical working of central station lighting. Having my own idea of the solution of the difficulty, I would like to have heard here from other people what the complete solutions are or else what are wanting. I think that would have added to the interest of the discussions on the alternating currents. I am sorry that I really have nothing to give you that would be of value to the association.

Dr. Moses—With regard to the question which Professor Forbes asks—about the measurement of alternating currents by meters—it is of course a most important question, and one lying at the very root of all electrical distribution.

Now, we come along to another period, when people had become familiarized with the handling of currents, and it has been desired to use the alternating currents for illuminating purposes. The alternating system has now been successfully introduced, but that link was wanting which the far-seeing mind of Mr. Edison supplied in his particular system of distribution by the electrolytic meter—the meter for the registration of the quantity of current consumed. Every one is familiar with the gas meter; every one knows that while it is somewhat unreliable, it may tell the truth; it generally does not; but still, it is a something. Now, in the alternating current distribution there has heretofore been no such thing. I am glad to say that I have had the privilege to inspect every part of the Westinghouse establishment during the past two days. And, among other things, I have seen a meter which I would take occasion to mention here as being one most admirably adapted to the registry of alternating currents, and with this excellent quality, that it will speak the truth, and with this corrolary to it—that we can verify it ourselves. I have to speak guardedly of this, because I was told at the time, that, while it was shown, still for certain reasons connected with the taking of European patents, and such things, it was not desirable that the particulars concerning it should be promulgated.

Mr. Lockwood—I would like to ask Professor Forbes a few questions with regard to underground wires in England. In 1881 and 1882 I had occasion to be in London, and investigate somewhat while there the underground wires of the arc light company—of two companies especially—and they were the Brush company, operating the Brush system, and the Electric Light & Power Generator Company, of London, operating the Weston system. I understood while there that within one year's time the Brush company were forced to renew three times their cables which they had laid down at Cheapside, in the lower part of London, and that each time they put in the kind of insulation that Professor Forbes speaks of as being preferable in England—the India rubber insulation; their cable being laid at that time by the India Rubber & Gutta Percha Company. I do not remember as to whether the Weston company had replaced theirs so many times; but I think they were replaced twice. I would like to ask Professor Forbes if he can give us a few points with regard to those companies, and whether they were ultimately successful in getting a cable which would stand the potential.

Professor Forbes—I cannot answer that quite fully. I can support your statement regarding the failure of the Brush company's cables; but I do not think that the statement is correct that they were the work of the India Rubber & Gutta Percha Company. I do not think that that was the case. The cables certainly were continually developing faults in different parts, and enormous quantities of the cables had to be laid; and, even when they were working at their best the insulation on the line varied enormously with the weather; so much so that, on some days, it was really almost impossible to work them. Eventually, as was stated just now, the whole of the cables had to be taken up. The best underground cables that I know of are at the works of the India Rubber & Gutta Percha Company, where they have had their cables lying for about six years, and are serving the whole of the arc lights in their large works. They are laid in a conduit, which, however, is not water tight, and the cables in some parts are dry, and in some parts are wet, and in other parts are alternately wet and dry; and they really undergo serious changes by the action of the water, as might be expected; and yet they have been maintained admirably during the whole of that time. I think that is all the information that I can give on that subject.

Mr. Morrison—I was not present when Mr. Leggett read his paper, and am not familiar with the details of it; but I wish to say this: Be careful how, as an association, you deal with the question of underground wires, and also be careful how you put yourself on record by taking the ground that such a plan of laying wires is not feasible. I do not intend to take any part in this discussion either pro or con. Of course I am opposed to underground wires. So is every man who has money invested in electric lighting. There are a whole lot of things that we are opposed to, but the reasons why we are opposed to them would not look well in print.

SESSION OF THURSDAY AFTERNOON.

The secretary read a communication from Mr. Benjamin Rhodes, manager of the Brush Electric Light Company, of Niagara Falls, inviting the association to meet at Niagara Falls next summer.

The committee on amendments to the constitution submitted the following report:

The committee on amendment of the constitution respectfully recommends that Article IV. of the constitution be amended to read as follows:

ARTICLE IV.

The president and vice-presidents shall be elected by ballot to serve from the close of the annual meeting at which they are elected until the close of the next annnal meeting, and the same person shall not be eligible for the office of president or vice-president for two successive terms.

The treasurer and secretary, who may be one and the same person, shall be nominated by the president subject to the approval of the executive committee, which shall have power to fix a proper compensation for his services, subject, however, to the approval of the association. The executive committee shall be chosen by ballot at each meeting either annual, semi-annual or special, to hold office from the close of the meeting at which they are elected until the end of the meeting at which their successors are chosen.

W. W. LEGGETT.
E. R. WEEKS.
S. A. DUNCAN.

Mr. Mason, moving that the report be laid upon the table, said: It is desirable, in the opinion of a number of the members of the association that several amendments should be made to this constitution, particularly, I might say, regarding the last article, which allows what seems to some to be rather loose action, namely, that amendments may be presented and acted upon at the same meeting of the association. But without particularizing further I have made this motion in order that we may have this whole question of the constitution brought before a competent committee who shall have time to consider it fully and report after due deliberation, that we may also have time to think the matter over and act consistently and intelligently.

The President—Before calling for a vote on this, I beg to remind you that in my judgment amendments should only be acted upon in full meetings. You have under consideration now a matter of the greatest importance to the future success of the association, and while I lay down the robes of authority so far as the presidential chair is concerned, yet I expect to be around when the other fellow is in the chair, and I would like to have a full expression on all matters of this kind, and I hope that neither Mr. Mason's notions nor Mr. DeCamp's suggestion shall be allowed to pass unnoticed. I beg that you will discuss them, turn them over and over and see how they look.

The motion to lay the report on the table was agreed to.

The President—The motion having been carried, the report of the committee will be the special order upon the first day of the reassembling of the convention.

Mr. Mason—I now move that a committee of five be appointed by the Chair on revision of the constitution.

The motion was carried, and the Chair appointed as the committee, Mr. Mason, Mr. Leggett, Mr. Phelps, Mr. Stanley and Mr. T. C. Smith.

Mr. Smith, declining on account of pressure of business, the President named Mr. Porter in his stead.

Mr. DeCamp moved that the salary of the secretary and treasurer be fixed at $900 dollars per annum.

The motion was agreed to.

The committee to nominate officers presented their report through Mr. Garratt, naming, for president, S. A. Duncan of the Allegheny County Light Company; for first vice-president, E. R. Weeks, of the Kansas City Electric Light Company; for second vice-president, A. J. DeCamp, of the Brush Electric Light Company, Philadelphia; for executive committee, Dr. Otto A. Moses, electrician, New York; chairman, J. Frank Morrison, Brush Electric Light Company, Baltimore; E. T. Lynch, Jr, United States Illuminating Company, New York; Frank Ridlon, of the Baxter Motor Company, Boston; W. L. Strong, of the Brush Illuminating Company, New York; T. C. Smith, of the Keystone Electric Light Company, Philadelphia; E. F. Peck, Citizens' Illuminating Company, Brooklyn.

The committee (to whom was also referred the place for holding the next meeting) recommended in their report that the next semi-annual convention be held in New York.

Mr. Leggett—It seems to me before voting for the executive committee, the question of the locality of the next meeting ought to be considered. If it should appear to the association that it might be desirable to have this meeting at Cincinnati, then, under our practice it would be desirable to have the chairman of the executive committee in that vicinity.

The President—I was going to say that if there be no objection the secretary will cast a ballot for president, and so along down, as you can only vote on one of these matters at a time. Are there any other nominations to be made than those made by the committee? There appear to be no further nominations and no objections to the vote ballots being cast by the secretary, so you can cast the vote.

The secretary then cast the ballots of the association, for Mr. S. A. Duncan, for president; Mr. E. R. Weeks for vice-president; for Mr. A. J. DeCamp for second vice-president.

The President—Gentlemen, I have the pleasure and honor of introducing to you your duly elected president, Mr. S. A. Duncan. He will find the office of president of this association a pleasant one if the same courtesies shall be extended to him as have been extended to me.

Mr. Duncan—Mr. President and gentlemen—I should be devoid of feeling did I not appreciate the honor you have conferred upon me, especially when I recognize that I am to succeed a man who, by his influence, as well as by the power of the gavel, which has been the only symbol of authority in this association, has welded together and made the association what it is to-day. Three years ago, in Chicago, a few representatives of electric lighting interests met and elected my predecessor, Mr. Morrison, as their president. From that time on he has continued to direct and control, with the advice and assistance of the executive committee, this association. It has grown in membership and influence until to-day it represents in its membership millions of capital and the intelligence and brains of the electric light interests of this country.

I shall endeavor, gentlemen, to bring to the discharge of the duties of president of this association, all the ability that I have. Promise is good, but performance is better, and you will be better able to decide upon the wisdom of your choice in the future than you are to-day, and I can only thank you for the compliment you have paid me and ask your indulgence for my failures and for probable inconsistencies in the rulings of the chair until such time as you have proper by-laws and parliamentary rules for your government. I have no doubt gentlemen, that you will place the same confidence and trust in the integrity of the chair of the future which you have in the past, and with your co-operation and assistance and with the aid of the retiring president, hope and trust that this association will do better, or as well at least, in the future, as it has done in the past

Again I thank you for your consideration. (Applause.)

There being no objection, the question of the next place of meeting was taken up before the election of the executive committee.

Mr. Foote, of Cincinnati, urged the selection of that city for the semi-annual meeting next August, calling attention to the Centennial celebration of the Ohio valley, to be held there from July to October, and the Industrial exhibition in connection with it, as advantages in favor of Cincinnati.

Mr. Leggett supported Mr. Foot's recommendation of Cincinnati for the next meeting.

Mr. Phelps moved that the recommendation of the committee be accepted, and that the next meeting be held at New York.

Mr. Leggett moved to amend by substituting Cincinnati for New York.

A vote being taken upon the substitute, it was defeated.

The original motion was then voted upon and agreed to, making New York the place of the annual meeting.

In proceeding to the election of an executive committee, the President pointed out that seven names were reported by the nominating committee, while the constitution provides for six.

At the suggestion of Mr. DeCamp, Mr. William L. Strong's name was stricken from that list, Mr. DeCamp stating that he had reason to believe that Mr. Strong would be unable to attend to the business of the committee.

There being no objection, the secretary then cast the ballot of the association for the following named gentlemen as members of the executive committee: Dr. O. A. Moses, Chairman; Mr. J. F. Morrison, Mr. E. T. Lynch, Jr., Mr. F. Ridlon, Mr. T. Carpenter Smith and Mr. E. F. Peck.

Discussion was then resumed on the papers read at the morning session.

Mr. E. B. Sunny—The statement was made this morning in the very excellent paper read by Mr. Leggett, that while it was entirely practicable to work telephone and telegraph wires underground, it was not practicable to do so with electric light wires. I remember distinctly that six years ago, when the question of putting wires underground in Chicago first came up, the telephone interest gathered its experts together, and in meeting assembled they each and every one of them avowed with all sincerity and earnestness that, while it was possible to work telegraph and electric light wires underground, it would be utterly impossible to operate telephone wires in that manner. The amount of crow that we have been compelled to eat in that time can be estimated upon when it is understood that there are 2,000 miles of underground wire working in Chicago to-day. As a matter of fact, the whole electrical interest opposed the measure and left no stone unturned to defeat it. The more they fought, the greater became the general clamor for the removal of the wires. The same thing occurred to which Mr. Leggett referred as having occurred in Detroit, the statements put forth in good faith and all truthfulness by the electrical fraternity, were discredited by everybody on the other side. The authorities exercised their power in its severest form by ordering the removal of every pole and wire from the public streets within a specified time. The prohibition included the entire city of forty-eight to sixty square miles, acres upon acres of which is vacant; miles upon miles of the streets of which are uninjured and sparsely settled, and alleys, in passing through which one instinctively holds his nose and breathes as little as possible.

The point that I think can be made is, that it is not the best policy to fight a measure in which the public seems to be so greatly interested, but to find a way to give them 10 or 15 per cent. of what they ask for, if in reason it can be done. I think now that had this course been pursued in Chicago, that we would now be able to string wires in the air outside of a limit of two or three square miles. Chicago has a thousand arc lights on underground circuits in the centre of the city, the greater number of which are in the districts served by the main station located on the Chicago river at Market and Washington streets. Most of the lighting is east of this point, so that twenty-five circuits, or fifty wires, run practically together for 2,000 or 3,000 feet.

When this station was established, several months ago, a conduit of twelve creosoted wooden tubes was put down to connect with the Dorsett conduit, built four years ago. The Dorsett conduit is made up of pipes having seven ducts, or holes, 2¼ inches each. Six lead cables of 3-32 inch insulation, No. 6 gauge, were drawn into the duct. Lead cables were used in preference to anything else, because of the difficulties experienced in maintaining the insulation where other makes—a good many of them considered first-class—had partly or wholly failed. Many of the conductors having no lead covering have done and are doing good service in various parts of the city, but in the business portion, where the earth is saturated with water gas and sewer gas, which circulates more or less freely through the conduit, nothing but lead seems capable of withstanding their influence. The six cables in each duct were made into three circuits—three positive and negative—and this arrangement is probably responsible for some of the trouble experienced. It was found that, although the insulation measurement of the lead cables in the conduit was very high—considerably above a megohm—and the insulation beyond the point where the lead cables ended and where some other wire was used was, say, 500,000 ohms, a short circuit would form, generally within 1,000 feet of the station, between the two sides of the circuit. The heat generated at the point of the short circuiting would melt the lead in the adjacent cables so that in one instance all six wires were rendered useless. Where this occurred in the Dorsett conduit the destruction did not go beyond the six wires, while in the creosoted wooden tubes on another occasion not only were the six wires destroyed, but the inflammable material of which the conduit is constructed resulted in the burning out of the entire conduit and the sixty cables in it. The cold weather of three months had frozen the earth to a depth of four feet, but when the street was opened it was found that the fire had taken the frost out of the earth below a foot from the surface, and that there was left for a distance of twelve feet a few charred sticks, the bare copper wires, and in the bottom some lumps of lead. Iron pipes were put in and lead cables of five-thirty-seconds insulation used—four of which were put in each duct or iron pipe. This heavier insulation coupled with the redistributing of the circuits so that positive wires are grouped and kept away from negative wires, will probably result in eliminating this source of trouble.

Looking for the cause of these burn-outs it was found that they occurred on circuits carrying as few as twenty lights, or 900 volts and 10 amperes, and on circuits carrying forty-eight lights, or 2,160 volts and 10 amperes. They generally occurred near the station, although there was an insulation of 6-32 inches between the two sides of the circuit measuring considerably above a megohm, and there were weaker places beyond, indicating that the nearer the station the greater is the liability of short circuiting.

It seems incredible that the 3-32 inch insulation around each conductor would not carry this voltage while the same make of cable of 2-32 inch carries a greater voltage in another part of the city. We could not in any instance of a burn-out find that an abnormal resistance had entered the circuit beyond the place where the burn-out occurred. On the contrary, as soon as the damage was repaired it was found that the circuit was in good order. Without being entirely at rest as to the exact cause of burn-outs, we have adopted what might be called a whip handle method of insulation—very heavy at the station and tapering towards the outer end of the circuit. This, it is expected, will enable the conductors to hold the current within them, under all conditions.

So much work has had to be done in the main route on account of the burn outs that we have had to make almost constant use of the man-holes in the conduit. We find now that these man-holes are all too small, and must be increased from 3 feet 6 inches diameter to 6 feet if possible. The suggestion is made that the latter size ought to be secured wherever possible, because of the impossibility of properly putting away the labyrinth of wires and cables that must be provided for at these points.

Mr. T. C. Smith—Our company here in Pittsburgh is probably as much interested as any in the country in aerial wires. We have a very large number of pole lines, and I do not know that we should feel inclined to take the whole of that wire down, and go underground within a year, or within two years. But it is very evident that the public demand is urgent that the wires be put underground wherever feasible, and our company has—without being asked by the city, and without any ordinances being passed to compel us—voluntarily undertaken to try the experiment thoroughly. We have seen a great many people try to put their wires underground, and in most cases which have come under my observation, the work has been done in such a manner that it is less a wonder that the cables burnt out than that they ever got current through them. As Mr. Smith, of Detroit, I think, has remarked, it is much more an economical question than an electrical one. With regard to one of the conduits of which Mr. Leggett spoke in his paper, the conduit in Chestnut street, Philadalphia, I happened at the very time that the conduit was being put down there to be connected with another company in Philadelphia which was also putting in underground conduits. The conduits which we laid were nothing but a lot of tin tubes put in a wooden box filled with pitch, and we hauled into it first-class, lead covered, insulated cables. We run them for six or seven months without the slightest hitch and without a single burn-out. At the time that the cast-iron conduit was laid in Chestnut street it was laid without any attempt whatever to keep it water-tight or air-tight. It was nothing but an iron trough in two parts, with putty along the edges. When the cables were put in (I saw a good many being put in) and in some of the cases where lead cables were used, the ends of the cable were simply ripped for two inches of the lead, the ends twisted, and three or four turns of kerite tape put around it; yet that has been cited as a dismal failure of underground wire. Now I am not by any means arguing that all wires must go underground, for the simple reason that companies that have spent an amount of money and have large vested interests in pole lines and wires and business cannot be compelled by any equity to remove the whole of that property and put it underground. In a great many cases it would be equivalent to sending the company out of business. But I do think that companies should endeavor, in the central parts of cities, where the streets are crowded and the buildings are high, and there is no doubt that the overhead wires are a nuisance, that they should make an honest endeavor to put them underground. With first-class work I see no reason why underground wires should not be successful. We have heard a great deal about the punching of holes through these cables. Any one who has had anything to do with arc light machinery knows that if you take a 40-light Thomson-Houston machine or a 60-light Brush machine and open the circuit suddenly you will discharge the field magnets into the line, and if there is any weak spot in the insulation it will go through it at that instant. We have demonstrated it over and over again. I think if the gentlemen who are trying underground wires will simply shut their dynamos down regularly by either short circuiting the armature or shunting the field circuit that they will do away with a great deal of this punching of holes in the cables. In laying down three or four miles of lead covered cables we cannot expect to find them perfect in every part. There will be pin-holes occasionally and the best inspection will not always discover them, but we have no right to assume because such things as that occur that the plan is impossible. There is not a man here present who has been in the electric business for a year who has not had a hundred cases of open circuits and short circuit on his overhead lines. The question is not whether undergound wires are feasible or not, but whether we cannot get them established with about the same trouble we took to get our overhead lines in position. I am interested in a company in Philadelphia which is running the underground system entirely. We started with a 200 volt direct current system. We knew that if we started that company the wires would have to be underground, that there were no more overhead ordinances going to be passed. We realized what we were attempting and we resolved to spare no expense to do the thing properly. When we purchased our cables from the company—they were all lead covered cables—we told that company to send us their most experienced men for the splicing and laying of those cables. We paid their expenses cheerfully. We not only had them make the joints but we watched them. We started at the station and turned the current into those lines. We ran there for six months without a trace of leakage, and then we changed over to the alternating system. We put a thousand volts into those cables, and they are running to-day and have been for nine months, without a single ground having occurred on them. We have fifteen miles of cable buried all told. We have had the question before us as to whether it would not be possible to run the alternating current in the same box with telephone and telegraph cables. At the request of chief Walker, the city electrician, we ran in the Long Distance Telegraph Company's conduit 1,500 feet of 3 conductor cable. On the two outer wires we put our alternating current, and we placed a 20-light converter into the chief's office. Into the third wire we connected his telephone, and there is not a trace of interference on it. The telephone company, of course, had given chief Walker permission to put that cable in their box, but they were a little nervous about the result, being afraid it would knock out their whole system between Philadelphia and New York. After we had been running about a week they came to us and wanted to know when we were going to start up. We told them that we had been running about a week, at which they were very

greatly surprised, and they have made no objection to the occupation of the box by us. Of course, I have had no real experience with arc lights underground—that is high tension currents—beyond the fact that when I put down my lead cables in Pittsburgh I used a 65-light Brush machine to test them with. I would not when testing them subject them to the strain of opening the circuit suddenly upon them.

I do not think it would be policy to do so. Chief Walker, in Philadelphia, is running some four or five miles of lead covered cable on his arc circuits. He has had one or two burn-outs. He had to string an air line for one section, because he could not dig up the streets, being winter. But he did not expect to put down a perfect job the first time. There is one thing I would like to ask some questions on. It has been stated that a direct current arc light cannot go underground. I do not think that the gentlemen who make that statement fully realize what a tremendous weapon they are putting in the hands of the press against them. I am not speaking now as an alternating current man, but as a member of the association, and as representing a lighting company which is interested in overhead wires in so far as they do not interfere seriously with public safety. We have proved beyond any question that the alternating current can be put underground and can be put in lead covered cables without any danger of loss of current. If the direct wires cannot go underground, the alternating can. And it may be that we shall be called upon to put in new apparatus which we do not want, simply because it cannot go underground. I think that in a case of this kind it is not the technical press we have to consider; they can realize the difficulty and danger and troubles of going underground. But it is the public press we have to consider. While they certainly do not always express public opinion they have a good deal with moulding it, and a persistent attack by the press on a lighting company will compel it to do what they desire. I think the sooner this question of underground wire is placed fairly the better it will be for all of us. I have had a good deal of consultation at various times with chief Walker, in Philadelphia, and he made the statement to me that some 18 months ago, before he would recommend the city to spend any money in the experiment, he wished to make a test of certain cable, and he got a length of 300 feet of cable. This was cut into two parts, and placed on the two poles—one on each pole of a Brush 65-light dynamo, laid in the yard of the station with the mud and water all around, and then connected with the air line. After they had run a few days a fault was developed in the cable and there was found to be a hole punched right through the insulation. I am not sure, but I think the other connection was found at the end of the wire, where it was bared to attach to the air line. The defective part was cut out and he has it in his office, and as I was under the impression that he had been using that wire in that way ever since, I telegraphed him this morning as follows: "Is the 300 feet of cable originally laid in the yard still in daily operation?" I received the answer from him: "To the best of my knowledge it is;" and I will ask Mr. Law whether that is the case or not.

Mr. Law—That cable has not been in use for the last five months at least.

Mr. Smith—Very good. Then chief Walker is mistaken. But at the same time he laid a good deal of cable in the upper part of the town, and that cable is still in use. Now the statement has been made that in Chicago the average capacity of the machines was 45 lights, and the average circuits 20 lights. I do not know—but I think the man in charge of the station has shown poor judgment in dividing his circuits.

Mr. Sunny—If you will allow me, I will explain that in one word—we have put out more circuits than the present business requires.

Mr. Smith—Exactly. I presumed you have done as I have done in Pittsburgh. I have kept all my circuits the size of my smallest unit. But the fact that the circuits and machines do not agree is no proof that it was done because the wire was defective. I would like to call on Mr. Wilber, of the Jenney company, who has laid a good deal of cable in Philadelphia; I would like to ask him if his cable is in use, and I would also like to ask Mr. Wilber to give his experience.

Mr. Wilber—I would say for the information of this association that last spring we laid over two miles of underground cable in Philadelphia, in the grounds of Girard College. We are running 47 lights on two 25-light machines. We have never experienced a particle of trouble with the cable from the time it was up to date. Where the cables came out at the top and connected with overhead wires there have been one or two grounds, leaks and lightning troubles, but no serious defect of the cable. But I am glad to think from our experience there, that there is some small grain of truth in the claim made that you cannot get as great a number of lights out of a given dynamo capacity in running underground as you can on overhead wires. With this exception I do not know that there is any serious difficulty in running arc light currents underground, unless it be that of expense, which is sometimes prohibitory.

Mr. Leggett—How long is the longest conduit that you have in the Girard College grounds?

Mr. Wilber—It is all one circuit. It is about two miles and one-eighth I should think. I do not remember the exact length. It is all one circuit of 47 arc lamps.

Mr. Leggett—You go out and come back through the same conduit?

Mr. Wilber—Yes, sir, side by side. It is the standard cable laid in creosoted boxes.

Mr. Law—I would like to ask Mr. Wilber if those conduits do not pass through passage-ways that go from one building to another, and if they are exposed in places to a very high degree of temperature.

Mr. Wilber—I neglected to state—and it is a very important matter—that the buildings of Girard College are heated by steam, and these steam pipes are carried through a brick conduit. We got the benefit of those brick conduits as far as they went from the engine room at the lower end of the grounds up to the furthest end of the building. We ran through this brick conduit, laid our wires in boxes in the conduit, and then branched out to the towers underground—laying it simply underground; and the duct is always heated in winter up to a very high temperature. I do not think there is any great amount of dampness.

The President—How much of your conduit runs in the duct?

Mr. Wilber—Perhaps from two-thirds to three-fourths of the entire circuit runs in the brick duct. Those branches out to the towers run through the ground.

Here Mr. Garratt asked permission to interrupt the discussion and offered the following:

Resolved, that the invitation courteously extended by Mr. H. C. Davis, president of the New York Electric Club, tendering the privileges of their house to the members of the association, be acknowledged, and accepted with the thanks of the association. The resolution was unanimously adopted.

Mr. DeCamp—Two papers have been read to-day on this subject of underground conductors—one for, and the other against; but there is one thing in which they both agree—perhaps two, but one in particular, and that is that we must have a perfect insulation. The second is that it is only a matter of cost. I believe that the first one is true, and no station will be operating a complete underground system until they secure that perfect insulation.

The question of cost is certainly one of very great importance. Electric lighting from central stations is now nine years old. There are organizations who have back of them probably as good business talent as ever backed up any new enterprise. They are waiting for their dividends yet. All know that the returns upon the capital invested in electric lighting have not been large. They have not been such as would justify the investment of money in a business which is likely to undergo rapid changes or rapid improvements, carrying with them a large depreciation in the value of their property. But the business which they are doing to-day is established—the prices are established—upon the basis of the cost of their present plants, and it is unnecessary to say that it would be utterly impossible for any company to go before the public to-day and advance the price of their lights. The prices of electric lights are high; they always have been; they are high to-day. They are lower than they were when they started; but they are high to-day. Therefore, you cannot advance your price. The cost of an underground conductor—those that are said to be reliable to-day—is four or five times as great as that of aerial wires. That must all be provided for.

It is claimed that expense of maintenance will be little or nothing. That I do not believe, from our own experience. I would not venture to say that until I had a very long experience.

In our lead covered cables there has been a tendency to short circuit between the wire and the lead; that shows an imperfect insulation. The lead does not protect when your insulation is imperfect. We put down a loop of 19,000 feet of lead cased cable placed in a box 6 inches square and filled in solid with pitch, joined to aerial wires, making a circuit of about 8 miles. That cable gave out once, through a short circuit between the conductor and the lead. It gave out again in the winter, the ground being frozen. Still another defect has compelled us to cut out a section between lamp posts all winter. There have been three explosions of gas in the man-holes within the last three months. Those are troubles that are purely, in my judgment, incidental to the conduit, but there has been other trouble which I think will always exist with lead cased wire, while it might not with some insulated cable without the lead.

Mr. T. C. Smith—I do not think two or three burn-outs on the first cable one lays has much bearing on the question of success of underground conduits. It is purely a question of policy for the companies. I do not believe there is a company that has a system of overhead wiring that could put their whole system underground without going into bankruptcy. The main question is can they not make some endeavor to put the central part of their wiring—in the central part of the city—underground? By-and-by I think that they will cut off a great deal of this public opposition to their wires. In Philadelphia ordinances have been passed allowing overhead wires to be put in the suburbs, but on the main graded streets of the city I think the electric light companies will find their best policy to put some of their wires underground.

On motion, duly carried, a committee on transportation for the next meeting was appointed by the President.

The following gentlemen were named as such committee: T. Carpenter Smith, of Pittsburgh; Mr. Geo. F. Porter, of New York, and Mr. Geo. S. Bowen, of Elgin, Illinois.

Dr. Moses—I have drafted resolutions which I know will meet with unanimous approval on the part of the convention. I will make no preamble because you all have in your minds whatever I would say on the subject. I will simply read the resolutions:

"*Whereas*, it has pleased Mr. J. Frank Morrison to insist upon not being re-elected to the position of President of the National Electric Light Association, which he has continuously held since its organization; and whereas, we have tacitly agreed at our successive re-elections of him to allow him to retire (as he has invariably requested at each meeting) whenever the interests of the association would not suffer by such action; therefore, be it

Resolved, That we, the National Electric Light Association of America, representing in our midst every department of electric light and power industry, express our deep regret at the decision of Mr. Morrison not to allow us to keep him at the helm, where, through many storms and quicksands, through much fair weather and some foul, he has successfully guided us to the haven where we now find ourselves; and be it further

Resolved, That a vote of thanks be given Mr. Morrison for the disinterested devotion, enthusiasm and steadiness with which he has administered the affairs and presided over the proceedings of our conventions; and that, further, we tender him our best wishes for his deserved enjoyment through a long and prosperous life, of the beautiful prospect of the great work he has done in founding, fostering and chartering the National Electric Light Association.

The resolutions proposed by Dr. Moses were seconded by Mr. Duncan, and were unanimously carried, when three cheers were given for Mr. Morrison.

Mr. Martin offered the following resolution:

Resolved, That the resolutions adopted in regard to the invaluable services of Mr. J. F. Morrison, as President for three years be suitably engrossed and presented to him, and that a committee be appointed to carry out this work and to make the presentation.

The resolution was adopted, and Mr. Martin and Dr. Moses appointed a committee to carry it out.

A vote of thanks was also given to Mr. H. Metzger, manager of the Pittsburgh Telephone Co., for the instrument placed at the disposal of the convention.

Mr. De Camp—I would like the privilege of offering the following resolutions:

Whereas, In the death of Mr. W. S. Frear, secretary of the Brush company, of Buffalo, N. Y., the association has sustained a severe loss;

Resolved, That the association hereby expresses its deep regret at being deprived of the fellowship and counsel of so young, promising and active a member, and that it further hereby tenders its sincere condolence to the many friends and the family of the deceased.

Resolved, That the secretary communicate the above resolutions to those who have been thus sorely bereaved.

The resolutions were unanimously adopted.

A telegram received from Mr. Arthur Steuart, chairman of the legal committee, dated at Washington, was read as follows: "Met the committee to-day; they are favorable to our plan."

Some further discussion on underground wires followed, by Mr. Wright, Mr. Eustis, Mr. De Camp, Mr. Lockwood, Mr. J. M. Smith, Mr. T. C. Smith, Mr. Law, Mr. Leggett and others—and at five o'clock the convention adjourned *sine die*.

THE PARIS ELECTRICAL LABORATORY.

While our own Electrical Standards Committee, instituted by the Society of Telegraph Engineers and Electricians, is apparently unable to get together the funds necessary for the establishment of a laboratory where electrical instruments could be officially tested in a manner similar to that adopted at Kew, for thermometers and watches, French electricians have progressed much better in this respect, the reason evidently being their command of a considerable fund which was left over from the Paris Electrical Exhibition of 1881. As the electrical laboratory in Paris will shortly be opened, a brief sketch of its history may be interesting to our readers. The Paris exhibition was not only scientifically and technically, but also financially, a great success, and at the close of it the general commissioner, M. G. Berger, was able to hand over to the Minister of Posts and Telegraphs the sum of £12,000, to be used eventually as a fund for the establishment of some kind of electrical laboratory. For a time the matter remained in abeyance, there being no public body of sufficiently strong position to initiate a work of such importance. But after the establishment of the International Society of Electricians, in 1883, with M. G. Berger as its first president, this society instituted a committee to report on the ways and means for establishing the laboratory, whilst the president took the necessary steps at the Ministry of Posts and Telegraphs in order to have the fund transferred to the control of the society. In due course, the secretary of the committee, M. E. Sartiaux, published a report containing particulars of various other electrical laboratories, and based upon this report the society definitely resolved to carry out the project for which the fund was originally intended. In this task they were well supported by private manufacturers, the Brothers Menier, for instance, giving them, rent free, land and buildings at No. 20, Rue Rouelle, in the Quartier de Grenelle; whilst a steam engine, a gas engine, and some electric machines and apparatus were lent, free of charge, by the respective makers. The buildings required some slight alterations, which were carried out under the superintendence of M. Dutreuil, the architect to the International Society of Electricians, but otherwise very little money was needed to complete the internal fittings of the laboratory. In consequence of this economy the greater portion of the fund is still intact, and the interest will be used to provide the working expenses. The society, now under the presidency of M. Mascart, has appointed M. de Nerville as general director of the laboratory. This gentleman is a telegraph engineer, and is well known in France for the work he did there years ago in connection with MM. Mascart and Benoist, in making a determination of the legal ohm. The programme of the laboratory is a fairly wide one. It is proposed that facility should be given to private individuals and manufacturers of electrical machinery for making researches which they could not carry on at their own laboratories or works. It is also proposed to standardize electrical measuring instruments, and to supply with each instrument which has been tested a certificate showing its limits of error; also to test electrical machinery generally, and to institute researches which the International Society of Electricians might deem of sufficient general utility.—*Industries.*

THE VIENNA ELECTRICAL LABORATORY.

The programme of this undertaking has just been issued by the Directors of the Technological Museum, of which the laboratory forms a recently added section. The work will be superintended by Herr Carl Schlenk, and is to embrace experimental investigations of dynamos as regards output, power consumed, efficiency, and other matters; investigations and reports on executed installations for lighting, power, or chemical purposes, photometry of arc and glow lamps, calibration of measuring instruments, and investigations of primary and secondary batteries. A tariff has been fixed for the work, which will presumably be required very frequently. Thus for testing a dynamo the charge will be from £1. 4s. to £4, according to size of machine; for testing a glow lamp, 16s. to £1. 4s.; arc lamp, £1. 4s. to £1. 12s.; calibration of instruments, 5s. to £1. 12s. Members of the museum obtain a discount of 25 per cent. off these charges. Where the work is of special nature, or for outside work, the charge is to be agreed upon beforehand. These fees are levied primarly with the object of covering working expenses. Any surplus is to be equally divided between the exchequer of the museum and the staff of the laboratory.—*Industries.*

ATMOSPHERIC TRAIN RESISTANCES.

Were it not for the resistance of the air, which at high speeds becomes an enormous factor of the total mechanical resistance, the possible speed of an electrically propelled railway train, might easily be made to approximate that of a projectile from a rifled gun. In view of this fact, the considerations presented by Mr. McElroy in a communication to the *Railroad Gazette*, are not without importance. He says:—

"As long ago, at least, as 1847 (Weale, London, 1847, and Glasgow Proc. Mech. Mag., vol. 2, p. 204), in making experiments on atmospheric resistance, Henry Bessemer (who afterwards invented the Bessemer process), from an ingenious apparatus arranged by him, found the front surface resistance of a car, at 20 miles per hour, 3.2 lbs. per square foot; at 30 miles, 4.5 lbs.; at 35 miles 6.1 lbs.; at 45 miles, 10 lbs. Each car added at 45 miles increased this resistance 4 lbs. per square foot, the total being, for a train of 8 cars, 18 lbs., and for 6 cars 30.5 lbs.

"The model train was then vestibuled car by car, and the result was the reduction of resistance, in the same ratio, of 4 lbs. per sq. ft. per car, the entire train, completely vestibuled, showing at 45 miles the face resistance of 10 lbs. due to a single car.

"Of course, running at speed againsta wind on the quarter-side, resistance would be affected by length, but these evidently are increased by successive openings between the cars. With the improved apparatus now at command, dynagraph experiments on vestibules for ordinary trains, if they proximately verify Mr. Bessemer's results, may lead to important changes.

"In modern practice, on the Erie canal, boats tow so much easier in *cue*, that this is now the common practice, and when they can be also vestibuled wave resistance will be greatly reduced."

THE TELEPHONE IN NOVA SCOTIA.

The Nova Scotia Telephone Co. formally took possession yesterday of the property and business of the Bell Telephone com-

pany, and the connections with the trunk lines leading to different parts of the province was effected. The toll rates from Truro and places beyond will be 25 cents for a conversation of five minutes. A toll for the shorter circuits has not yet been fixed; it will probably be 15 cents. The central office system of the two companies are somewhat different. The Bell system will be continued for the present, but as it is claimed the other company's is the most satisfactory it may be substituted later on. Mr. A. A. Knudson, superintendent of the Nova Scotia company, takes charge of the affairs, Mr. Edwards retaining his present position and the staff of employés remaining the same.—*Morning Chronicle*, Halifax, Feb. 4.

THE AMERICAN ELECTRIC MANUFACTURING COMPANY.

The manufacturing and the selling departments of this company are hereafter to be conducted by separate corporations. A new company has been formed under the title, The American Electric Construction Co., of New York, for the sale of the product of the Manufacturing company throughout the United States, excepting New England. A similar corporation will, it is understood, be formed in Boston, for supplying the New England states. Mr. Edwards H. Goff will continue at the head of the American Electric Manufacturing Co., assisted by Col. H. C. Adams, secretary and treasurer; Mr. A. R. Brown, now general manager of the Electrical Development and Manufacturing Co., in Boston, and Mr. B. H. Cook, the present superintendent of the Eighteenth street factory. Mr. Wood, electrician of the American Electric Manufacturing Co., will have his laboratory and experimental rooms greatly enlarged in the new factory, where will be concentrated the manufacturing now carried on in different premises.

PENNSYLVANIA STATE COLLEGE.

AN ELECTRICAL COURSE TO BE ESTABLISHED.

The trustees of Pennsylvania State College, at their meeting in January, 1888, adopted a four years' course in physics and electrotechnics. A new building for physical lecture room and laboratories is begun. An appropriation from the state will add considerably to the equipment for physical and electrotechnical work.

Under Professor I. Thornton Osmond, in charge of the department of physics, the course in electricity is quite certain to be adequately planned and conducted.

ELECTRIC LIGHT AND POWER.

THE EDISON ELECTRIC LIGHT Co., of Philadelphia, Pa., are about to increase their plant in that city. They will require additional boiler capacity to the extent of 3,450 h. p., and after a most rigid investigation, have decided to use the Abendroth and Root Safety Boiler, as being well adapted for electric lighting purposes. The Abendroth and Root Manufacturing Co., 28 Cliff street, New York, are now at work upon the first portion—850 h. p.—the remainder to follow as soon as buildings can be prepared.

THE WESTINGHOUSE ELECTRIC COMPANY has still a large force of workmen engaged in putting their converter system in the Hoosac Tunnel, the completion of which work has been retarded from several causes. Workmen find frozen ground and ice where excavations are to be made for conduits, extending about a mile from each portal. This is an unexpected obstacle to overcome, as observations of previous years place the frost line only about half a mile from the portals. The men have imperative orders to cease work as soon as a train is heard approaching and to seek safety in the man-holes on the sides of the tunnel. The conduits are of ¾ in. Canadian pine, seasoned three years, soaked in tar and oil compound, and painted with tar outside before laying in the trench. This excludes all moisture. The wire used is from the Standard Underground Cable Company, of Pittsburgh. About sixty miles of wire will be used for main cable and lamp connections. The lamps are to be hung on the side walls of the tunnel about six feet from the top of the rails. There will be 1,250 lamps of twenty-five candle-power each, fastened to the wall by Ahlstrom's expansion bolt. Workmen are now drilling holes for the bolts near the west portal. On account of the sulphurous gases and moisture, all metallic work on the lamps is done away with as far as possible, the remainder being securely protected.

Foreign.

Belgium.—THE LIGHTING OF THE BRUSSELS EXHIBITION.—The executive committee are making arrangements for the division of the lighting of the exhibition, the total light required being about 600,000 c. p., distributed among 1,200 glow lamps and 350 arc lamps. English and Belgian electricians are taking the principal part, French and German firms being less prominently represented. The motive power is supplied free, 500 h. p. being available for the buildings and 500 h. p. for the gardens. For the illuminated fountains, there will be a separate installation, with 100 h. p. M. Pieper, with Mr. Sennett, will take up this section. The Thomson-Houston, Edison, and Bernstein companies, M. Bouckaert, and M. Dulait will undertake portions of the lighting, for which very advantageous offers have been received. Paris and Brussels firms have undertaken the gas lighting on almost gratuitous terms.

Germany.—According to the presidential address of Dr. von Stephan, at the Berlin Society of Electricians, there are at present in use throughout Germany 15,000 arc lamps and 170,000 glow lamps, supplied with current from about 4,000 dynamos. Dr. von Stephan estimates that an arc lamp requires on an average ¾ h. p. and a glow lamp ⅛ h. p. On this basis the total horse-power employed in electric lighting throughout Germany amounts to 30,000 h. p. The Berlin gas works have also recently collected statistics regarding the extent to which the electric light is introduced in this town. It appears that 1554 arc lamps, 22,363 glow lamps, and 333 dynamos are installed. The town authorities are now negotiating for a new contract with the Electricity Supply Works, under which the cost of installation for glow lamps would be diminished by 18 per cent., and that for arc lights by 27 per cent., as compared with the prices at present charged, whilst the company undertake to pay a fine in case of failure or delay in putting up an installation. When the installation is put up to the order of the town authorities a fine of £2. 10s for every day's delay will be imposed, whilst for non-delivery of current to private consumers within four weeks after the installation is put up, the fine is £1 per day. The old market in this town was one of the first places lighted by arc lamps, but the installation has not proved very successful. The lamps were grouped in parallel series of two, and in some cases the conductor was iron wire. The buildings are very scattered, and supervision was not easy, consequently break-downs were of frequent occurrence. Now that the municipality have determined to erect new markets in the various suburbs of this town, they propose to light these by gas. It is, however, likely that better counsels will prevail, and that the corporation will adopt arc lamp installations where the lamps are in single parallel, and the potential is maintained at 65 volts.

MANUFACTURING AND TRADE NOTES.

THE EXCELLENCE of the vulcanized rubber belting, manufactured by the N. Y. Belting and Packing Company, 15 Park Row, N. Y., for use in all lines of manufacture, is becoming more apparent daily. This company who are the oldest and largest manufacturers in the United States of vulcanized rubber goods for mechanical purposes, have lately placed upon the market a superior quality of belting with smooth metallic surface for electric light purposes.

THE REPORT of the commissioners relative to the insulated electric wires on the United States steamship "Atlanta," was extremely favorable to the Okonite Co., of New York. It is reported that the Lord Commissioners of the Admiralty of England, after a trial at Portsmouth, report that the Okonite wires in use by them have proven eminently satisfactory.

MESSRS. WOODHOUSE AND RAWSON, of London, England, have been awarded a gold medal at the exhibition at Saltaire, Yorkshire, for excellence of their goods and installation work, and a bronze medal at Newcastle, for their Scharnweber arc lamps (80 lighting the grounds).

A. L. BOGART, 22 Union square, New York, announces that improvements in electric gas-lighting burners, patented to Leroy S. White, February 7th (No. 377,505), have been applied to the "Bartholdi" automatic burners. The improved "Bartholdi" automatic is a very compact piece of mechanism, and is said to be reliable and best made.

MESSRS. PARTRICK AND CARTER, of Philadelphia, send us their latest catalogue and price list (1888) of annunciators, bells, burglar alarms, etc. The list of this old and well-known house embraces outfits meeting a great variety of domestic applications of electricity—including hotel equipments for guest calls, time calls, and fire-alarms. Electric gas lighting appliances constitute a feature of the business of Messrs. Partrick and Carter. Their list of general electrical supplies is very complete. The reputation of this house dates far back among the early days of electrical business.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horse-power; **T.**, T-rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scafe; *Sec.*, Arthur Kennedy; *Supt.*, J. J. Houghton; *Eng.*, Sam'l Drescher; 4 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 250 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Supt.*, G. Johnson; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; water-power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Denver, Col.—Denver Tramway Co.—*Pr.*, Rodney Curtis; *Sec.*, Wm. G. Evans; *Supt.*, Jno. C. Curtis; 4 mi.; g. 36; 16 and 18 lb.; 10 m. c.; sta. 125 h. p.; conduit cond. SHORT-NESMITH.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g. ——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE.
Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; 1 mi.; g. 5-2; 56 lb.; 2 m. c.; sta. 80 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1 c.; 1 m.; sta. —— h. p.; conduit cond. VAN DEPOELE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, Chas. D. Haines; *Sec.* F. H. Skeele; 1.5 mi.; g. 4-8½; 25 lb. T.; 2 m. c.; sta. 50 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Kansas City, Mo.—Kansas City Elect. Ry. Co.—*Pr.*, W. W. Kendall; *Sec.* & *Tr.*, Warren Watson; *Supt.* John C. Henry; 2 mi.; g. 4-8½; 70 lb.; 4 m. c.; sta. 80 h. p.; overhead cond. HENRY.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. VAN DEPOELE.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair Ry. Co.—*Pr.*, Theo. Evans; *Sec.*, J. W. Patterson; 2 mi.; g. 5-2½; 45 lb.; 5 c.; 5 m.; sta. 175 h. p.; overhead and conduit cond. DAFT.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. VAN DEPOELE.

Richmond, Va.—Union Pass. Ry. Co.—*Pr.*, J. T. Brown; *Sec.* and *Treas.*, J. F. Barry, *G. M.*, G. H. Burt; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 375 h. p.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.* Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. M. Waugh; 5.75 mi.; g. 4-8½; 30 lb.; 3c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Supt.* B. T. Killam; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 7 m. c.; sta. 360 h. p.; overhead cond. VAN DEPOELE.

Wichita, Kas.—Wich. Riverside & Suburban Ry. Co.—*Pr.*, J. O. Davidson; *Sec.*, N. G. Lee; 4 mi.; g. 6-8; 45 lb; 6 m. c.; sta. h. p.; overhead cond.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.75 mi.; g. 3-6; 35 lb.; 1 c.; 2 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb. T; 1 m. c.; sta. 1,000 h. p.; overhead cond. BENTLEY-KNIGHT.

Constructing or Under Contract.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½: 45 lb.; 3 m. c.; 1 m.; sta —— h. p.; overhead cond. VAN DEPOELE.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—6 mi.; g. 4-8½; —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond. SPRAGUE.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; 5 mi.; g. 4-8½; 25 and 56 lb.; overhead cond. SPRAGUE.

Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown. VAN DEPOELE.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper. DAFT.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. VAN DEPOELE.

Elsinore, Cal.—Elsinore Lake Shore Elect. Ry. Co.—*Pr.*, D. G. Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; 6 m. c.; overhead cond. SPRAGUE.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.

New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*. E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.

New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.

Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.

Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.

Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.

St. Louis, Mo.—Lindell Ry. Co.—*Pr.* J. H. Maxon; *Sec.* and *Tr.* G. W. Baumhoff; —— mi.; g. 4-10; storage bats.

San Jose, Cal.—San Jose Motor Co.—*Pr.*, J. W. Rea.

Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.*, A. Frothingham; *G. M.*, B. F. Killam; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; overhead cond. VAN DEPOELE.

South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.

Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; 3.25 mi.; g. 4-8½; overhead cond. DAFT.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond.; VAN DEPOELE.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—7 mi.; g. 5-2; 50 lb.; 2 m. c.; overhead cond. SPRAGUE.

Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 115 *Nassau street, New York city.*

ANTHONY AND BRACKET'S PHYSICS.

[88.]—In the ELECTRICAL ENGINEER, for February, there appears a criticism of Anthony and Bracket's Physics, in which it appears your reviewer has examined the part on electricity and magnetism from one side only, and thus failed to appreciate the excellence of the work. The book was not conceived to be of particular value to "practical workers" or to be "elementary" in the sense intended by the reviewer. Its true place is the class rooms of our technical colleges, for use in conjunction with a thorough course of lectures, which show the practical applications of the "definitions and resultant formulæ." When viewed from this stand-point the book shows great excellence in the selection of matter, and the manner in which the subject is presented. The proper teaching of this book cannot but give *earnest* students the best foundation on which to build a thorough course of electrical engineering, theoretical and practical. D. C. JACKSON.

LINCOLN, Neb., Feb. 6, 1888.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From Jan. 24th, to Feb. 14, 1888 (inclusive).

Alarms and Signals:—*Electric Call*, W. H. Cutting, 376,863, Jan. 24. *Electrical Auxiliary Signaling System*, G. F. Milliken and H. B. Lytle, 377,083. *Electric Annunciator*, J. W. Hoffman, 377,256, Jan. 31. *Electric Bell*, W. F. Stocker, 377,539. *Electro-Mechanical Signal Apparatus*, W. W. Le Grande, 377,626, Feb. 7. *Electric Bell*, J. P. Tirrell, 377,916, Feb. 14.

Clocks:—*Secondary Electric Clock*, W. B. Harvey, 377,895, Feb. 14.

Conductors, Insulators, Supports and Systems:—*Electrical Conductor*, T. Egleston, 376,818. *Underground Conduit for Electric Wires*, E. C. Lindemann, 376,898, Jan. 24. *Insulating Electric Conductors*, R. Schefbauer, 377,118, Jan 31. *Support for Electric Conductors*, M. J. Hart, 377,894. *Tubular Metallic Pole for Telegraphic and other Uses*, A. Mills, 377,953. *Underground Electrical Conduit*, R. F. Silliman, 378,021, Feb. 14.

Distribution:—*System of Electrical Distribution*, J. W. Howell, 377,488, Feb. 7. *System of Electrical Conversion*, E. N. Dickerson, Jr., 377,994, Feb. 14.

Dynamos and Motors:—*Armature for Dynamo-Electric Machines*, E. J. O'Beirne, 377,046. *Alternating Current Motive and Regulating Device*, E. Thomson, 377,217. *Electric Motor*, E. M. Bentley, 377,230. *Regulation of Electric Motors*, D. Higham, 377,255. *Electric Motor*, C. T. Mason, Sr., 377,319, Jan. 31. *Armature for Dynamo-Electric Machines*, R. H. Mather, 377,683, Feb. 7. *Current Regulator for Dynamo-Electric Machines*, W. A. Crodus and H. M. Sutton, 377,884. *Dynamo-Electric Machine*, R. Eickemeyer, 377,996. *Frame for Winding Armatures*, same, 377,997, Feb. 14.

Galvanic Batteries:—*Galvanic Battery*, D. Urquhart and B. Nicholson, 377,340, Jan. 31. *Galvanic Battery*, T. M. Foote, 377,745, Feb. 14.

Ignition:—*Electric Gas-Lighting Burner*, L. S. White, 377,505. *Electric Gas-Lighter*, J. Finck, 377,553, Feb. 7. *Electric Fuse*, P. G. Gardner, 377,851, Feb. 14.

Lamps and Appurtenances:—*Electric Arc Lamp*, E. E. Higgins and J. James, 377,615, Feb. 7.

Medical and Surgical:—*Therapeutic Electric Belt*, S. B. Bushfield, 376,730, Jan. 24. *Electric Belt*, G. W. Totman and P. C. Totman, 377,218, Jan. 31. *Electro-Medical Apparatus*, T. R. Ten Broeck, 377,872, Feb. 14.

Metallurgical:—*Magnetic Separator*, T. A. Edison, 377,518, Feb. 7.

Miscellaneous:—*Mechanism for Electrical Connections*, P. W. and J. B. Wood, 376,973. *Electrical Switch*, S. Bergmann and J. T. Dempster, 376,976, Jan. 24. *Protecting Device for Electrical Apparatus*, A. S. Hibbard, 377,078. *Electrolyte Compound*, G. B. Pennock, 377,210, Jan. 31. *Electro-Magnetic Grain Weighing Scale*, W. A. Holley and U. Malin, 377,383. *Embroidering Machine*, R. T. Smith, 377,408, and 377,409. *Electrical Apparatus for Effecting Mechanical Movements*, same, 377,413. *Process of Electrolyzing Copper*, E. S. Hayden, 377,487. *Electric Circuit Closer*, J. F. Stocker, 377,538. *Electro-Mechanical Movement*, R. H. Mather, 377,684, Feb. 7. *Lightning Rod Attachment for Windmills*, E. O. Daniels, 377,742. *Electric Current Indicator*, E. P. Warner, 378,029, Feb. 14.

Railways and Appliances:—*Electric Railway*, R. M. Hunter, 377,167. *Traveling Current-Collector for Electric Railway Motor Cars*, W. M. Schlesinger, 377,215. *Electric Locomotive*, E. M. Bentley, 377,229, Jan. 31. *Electric Railway*, W. A. Ludlow, 377,397. *Electric Motor Car*, W. H. Knight, 377,622. *Railway Signal*, T. S. Nicholson, 377,634, Feb. 7.

Secondary Batteries:—*Secondary Battery*, J. S. Sellon, 377,642, Feb. 7.

Telegraphs:—*Telegraph Instrument*, W. S. Logue, 377,110. *Plug-Switch for Telephone and Telegraph Circuits*, G. H. Cole, 377,287. *Railway Telegraph*, C. W. Williams, 377,344, Jan. 31. *Telegraphy*, T. A. Edison, 377,374, Feb. 7. *Printing Telegraph*, J. H. Linville, 377,763. *Combined Telegraph Key and Sounder*, B. Oehmen, 377,862. *Telegraphy*, C. Ader, 377,879, Feb. 14.

Telephones, Systems and Apparatus:—*Transfer Switch and Circuit for Telephone Exchanges*, C. E. Scribner, 377,441. *Telephone Transmitter*, J. F. Bahr, 377,475. *Telephone Transmitter*, H. V. Hayes, 378,612, Feb. 7. *Telephone System*, E. P. Thayer and G. H. Kugler, 377,788. *Telephone Exchange Central Office Connection*, E. P. Warner, 378,030. *Telephone Transmitter*, T. A. Edison, 378,044, Feb. 14.

THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS, JR.

PUBLISHED MONTHLY BY

THE ELECTRICAL PUBLISHING CO.,

115 Nassau Street, New York city.

TERMS OF SUBSCRIPTION.

United States and Canada, per annum,	$3.00
Four or more Copies, in Clubs (each) "	2.50
One Copy, Four Months,	1.00
Great Britain and other Foreign Countries within the Postal Union "	4.00
Single Copies, -	.30

[*Entered at the Post Office at New York, N. Y., as second class mail matter.*]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of the* ELECTRICAL PUBLISHING CO. *Communications for the attention of the editors should be addressed*, EDITOR OF THE ELECTRICAL ENGINEER, 115 *Nassau Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers*

VOL. VII. SUPPLEMENT—MARCH 22, 1888.

SUPREME COURT OF THE UNITED STATES.

The Telephone Appeals.

AMOS E. DOLBEAR, *et. al.*, *Appellants*, *v.* THE AMERICAN BELL TELEPHONE CO.	U. S. C. C. Mass.
THE MOLECULAR TELEPHONE CO., *et. al.*, *Appellants*, *v.* THE AMERICAN BELL TELEPHONE CO., *et. al.*	U. S. C.C. S. D. N. Y.

[Cross Appeal in the Same Case.]

THE CLAY COMMERCIAL TELEPHONE CO., *et al.* *v.* THE AMERICAN BELL TELEPHONE CO., *et al.*	U. S. C. C. E. D. Pa.
THE PEOPLE'S TELEPHONE CO., *et al.*, *Appellants*, *v.* THE AMERICAN BELL TELEPHONE CO., *et al.*	U. S. C. C. S. D. N. Y.
THE OVERLAND TELEPHONE CO., *et al.*, *Appellants*, *v.* THE AMERICAN BELL TELEPHONE CO., *et al.*	U. S. C. C. S. D. N. Y.

WASHINGTON, D. C., March 19, 1888.

The CHIEF JUSTICE—I have been instructed by the Court to announce its judgment this morning in the six cases known as the telephone cases, and as the opinion is rather long, and my voice is weak and not under control, I have asked Judge Blatchford to read it.

Mr. JUSTICE BLATCHFORD—This opinion is in case No. 118, *Amos E. Dolbear* and other appellants, versus *The American Bell Telephone Co.*, an appeal from the Circuit Court of the United States for the District of Massachusetts.

In cases No. 361 and 362, which are cross-appeals from the Circuit Court of the United States for the Southern District of New York, one by the *Molecular Telephone Co.* and others, appellants, against *The American Bell Telephone Co.* and another, and a cross-appeal by *The American Bell Telephone Co.* and another, versus *The Molecular Telephone Co.* and others.

Another case is No. 709, *The Clay Commercial Telephone Co.* and others, appellants, versus *The American Bell Telephone Co.* and others; an appeal from the Circuit Court of the United States for the Eastern District of Pennsylvania.

Another is case No. 770. *The People's Telephone Co.* and others, appellants, against *The American Bell Telephone Co.* and others, an appeal from the Circuit Court of the United States for the Southern District of New York.

Another is case No. 771, *The Overland Telephone Co.* and others, appellants, against *The American Bell Telephone Co.* and others, an appeal from the Circuit Court of the United States for the Southern District of New York.

The opinion is written by the Chief Justice.

BELL'S CLAIM FOR THE ART.

The important question which meets us at the outset in each of these cases, is as to the scope of the fifth claim of Bell's patent of March 7, 1876, which is as follows:

> The method of and apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth.

It is contended that this embraces the art of transferring to or impressing upon a current of electricity, the vibrations of air produced by the human voice in articulate speech, in such a way that the speech will be carried to and received by a listener at a distance on the line of the current. Articulate speech is not mentioned by name in the patent. The invention as described, consists in the employment of a vibratory or undulatory current of electricity, in contradistinction to a merely intermittent or pulsatory current, and of a method of, and apparatus for producing electrical undulations upon the line wire.

A pulsatory current is described as one caused by sudden or instantaneous changes of intensity, and an electrical undulation as the result of gradual changes of intensity, exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations.

Among the uses to which this art may be put, is said to be the telegraphic transmission of noises or sounds of any kind; and it is also said that the undulatory current, when created in the way pointed out, will produce through the receiver at the receiving end of the line, a similar sound to that uttered into the transmitter at the transmitting end. One of the means of imparting the necessary vibrations to the transmitter to produce the undulations may be the human voice. Articulate speech is certainly included in this description, for it is an uttered sound produced by the human voice.

It is contended, however, that "vocal sounds" and "articulate speech" are not convertible terms, either in acoustics or in telegraphy. It is unnecessary to determine whether this is so or not. Articulate speech necessarily implies a sound produced by the human voice. As the patent, on its face, is for the art of changing the intensity of a continuous current of electricity by the undulations of the air caused by the sonorous vibrations, and speech can only be communicated by such vibrations, the transmission of speech in this way must be included in the art. The question is not whether vocal sounds and articulate speech are used synonomously as scientific terms, but whether articulate speech is one of the vocal or other sounds referred

to in this claim of the patent. We have no hesitation in saying that it is, and that if the patent can be sustained to the full extent of what is now contended for, it gives to Bell, and those who claim under him, the exclusive use of this art for that purpose until the expiration of the statutory term of his patented rights.

In this art, or what is the same thing under the patent law, this *process*, this *way* of transmitting speech, electricity, one of the forces of nature, is employed; but electricity left to itself will not do what is wanted. The art consists in so controlling the force as to make it accomplish the purpose.

It had long been believed that if the vibrations of air caused by the voice in speaking could be reproduced at a distance by means of electricity, the speech itself would be reproduced and understood. How to do it was the question. Bell discovered that it could be done by gradually changing the intensity of a continuous electrical current, so as to make it correspond exactly to the changes in the density of the air caused by the voice. This was his art. He then devised a way in which these changes of intensity could be made and speech actually transmitted. Thus his art was put in a condition for practical use. In doing this, both discovery and invention, in the popular sense of those terms, were involved; discovery in finding the art, and invention in devising means of making it useful; and for such discovery and such invention, the law has given the discoverer and inventor the right to a patent; as discoverer, for the useful art, process and method of doing the thing he has found, and as inventor, for the means he has devised to make the discovery one of actual value. Other inventors may compete with him for the ways of giving effect to the discovery, but the new art he has found will belong to him and those claiming under him, during the life of his patent. If another discovers a different art or method of doing the same thing, reduces it to practical use, and gets a patent for his discovery, the new discovery will be the property of the new discoverer, and thereafter the two will be permitted to operate, each in his own way, without interference by the other. The only question between them will be whether the second discovery is in fact different from the first.

A patent for the art does not necessarily involve a patent for the particular means employed for using it. Indeed, the mention of any means in the specification or descriptive portion of the patent, is only necessary to show that the art can be used; for it is only useful arts, arts which may be used to advantage, that can be made the subject of a patent. The language of the statute is:

> Any person who has invented or discovered any new or useful art, machine, manufacture or composition of matter may obtain a patent.

That is section 4886 of the Revised Statutes. It is an art, a process which is useful, and is as much the subject of a patent as a machine, manufacture or composition of matter. Of this there can be no doubt. It is abundantly supported by the authorities. *Corning* v. *Burden*, 15 How., 252-271. *Tilghman* v. *Proctor*, 12 How., 707-735. *Fermentation Company* v. *Maus*, 20 Fed. Rep., 725.

What Bell claims, is the art of creating changes of intensity in a continuous current of electricity exactly corresponding to the changes of density in the air caused by the vibrations which accompany vocal or other sounds, and of the use of the electric condition that is thus created for sending and receiving articulate speech telegraphically. For that, among other things, the patent of 1876 was, in our opinion, issued, and the point to be decided is, whether as such a patent it can be sustained.

In *O'Reilly* v. *Morse*, (15 How.) it was decided that a claim in broad terms for the use of the motive power of the electric or galvanic current for making intelligible characters, letters or sounds at any distance, although a new application of the power was made by Morse, was void, because it was a claim for a patent for an effect produced by the use of electro-magnetism, distinguished from the process or machinery necessary to produce it.

But a claim for making use of the motive power of magnetism when developed by the action of said current, substantially as set forth in the foregoing description, as a means of operating or governing the motion or machinery that is to impart signals in any desired manner for the purpose of producing telegraphic communication at any distance, was sustained. The effect of the decision was, therefore, that the use of magnetism as a motive power, without regard to the particular process with which it was connected in the patent, could not be claimed; but that its use in such a connection could.

In the present case the claim is not for the use of a current of electricity in its natural state, as it comes from the battery; but for putting a continuous current in a closed circuit into a certain specific condition suited to the transmission of vocal and other sounds, and using it in that condition for that purpose. So far as at present known, without this peculiar change in its condition, it will not serve as a medium for the transmission of speech, but with the change it will. Bell was the first to discover this fact and how to put such a current into such a condition. What he claims is its use in that condition for that purpose, just as Morse claimed his current in his condition for his purpose. But we see nothing in the Morse case to defeat Bell's claim. On the contrary it is in all respects sustained by that authority. It may be that electricity cannot be used at all for the transmission of speech except in the way Bell has discovered it, and that, therefore, practically his patent gives him its exclusive use for this purpose. But that does not make his claim one for the use of electricity as distinguished from the particular process with which it is connected in his patent. It will, if it is true, show more clearly the great importance of his discovery, but it will not invalidate his patent.

SUFFICIENCY OF THE SPECIFICATION.

But it is insisted that his claim cannot be sustained, because when the patent was issued Bell had not, in fact, completed his discovery. While it is conceded that he was acting on the right principle and had adopted the true theory, it is claimed that his discovery lacked that practical development which was necessary to make it patentable. In the language of counsel "there was still work to be done, work calling for the exercise of the utmost ingenuity and calling for the very highest degree of practical invention."

It is quite true that when Bell applied for his patent he had never actually transmitted telegraphically spoken words so that they could be distinctly heard and understood by the listener at the receiving end of his line, but in his specification he did describe accurately and with admirable clearness, his process, that is to say the exact electrical condition that must be created to accomplish the purpose. He also described with sufficient precision to enable one skilled in such matters to make it, a form of apparatus, which if used in the way pointed out, would produce the required effect, receive the words and carry them to and deliver them at the appointed place. The particular instrument which he had, and which he used in his experiments did not under the circumstances in which it was tried, reproduce the words spoken so that they could be clearly understood; but the proof is abundant and of the most convincing character that other instruments carefully constructed and made in exact accordance with the specifications without any additions whatever have operated and will operate successfully. A good mechanic of proper skill in matters of the kind can take the patent and by following the specification strictly, can, without more, construct an apparatus which when used in the way pointed out, will do all that it is claimed the method or process will do.

Some witnesses have testified that they were unable to

do it, but this shows that they, with the particular apparatus they had and the skill they employed in its use, were not successful; not that others with another apparatus perhaps more carefully constructed or more skilfully contrived would necessarily fail. As was said in *Loom Company* v. *Higgins*, when the question is whether a thing can be done or not, it is always easy to find persons to show how not to do it. If one succeeds, that is enough, no matter how many others fail. Opposite results will show that in the one case the apparatus used was properly made, and carefully adjusted with a knowledge of what was required, and skillfully used; and that in the other it was not. The law does not require that a discoverer or inventor, in order to get a patent for a process, must have succeeded in bringing the art to the highest degree of perfection. It is enough if he describes the method with sufficient clearness and precision to enable those skilled in the matter to understand exactly what the process is, and if he points out some practicable way of putting it in operation. This Bell did.

He described clearly and distinctly his process of transmitting speech telegraphically by creating changes in the intensity of a continuous current or flow of electricity in a closed circuit, exactly analogous to changes of density in the air occasioned by the undulatory motion given to it by the human voice in speaking. He then pointed out two ways in which this might be done, one, by the vibration or motion of bodies capable of inductive action or by the vibration of the conducting wire itself in the neighborhood of such bodies; and the other by alternately increasing and diminishing the resistance of the circuit or by alternately increasing and diminishing the power of the battery. He then states that he prefers to employ for his purpose an electro-magnet having a coil on one of its legs, and he describes the construction of the particular apparatus, shown in the patent as figure 7, in which the electro-magnet or magneto method was employed. This was the apparatus which he himself used without entirely satisfactory results, but which Professor Cross, Mr. Watson, Doctor Blake, Mr. Pope and others, testify has done and will do what was claimed for it, transmit speech successfully, but not as well indeed as another constructed upon the principle of the microphone or variable resistance method.

THE PATENT NOT LIMITED TO SPECIFIC APPARATUS.

An effort was made in the argument to confine the patent to the magneto instrument, and such modes of creating electrical undulations as could be produced by this form of apparatus, the position being that such an apparatus necessarily employed a closed circuit incapable of being opened, and a continuous current incapable of being intermittent. But this argument ignores the fact that the claim is, first, for the process and, second, for the apparatus. It is to be read, as *first*, a claim for the method of transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations similar in form to the vibrations of air accompanying the vocal or other sounds substantially as set forth, and, *second*, for an apparatus for transmitting vocal or other sounds telegraphically as herein described, by causing electrical undulations, substantially as set forth.

The *method* "as herein described" is to cause gradual changes in the intensity of the electrical current used as the medium of transmission, which shall be exactly analogous to the changes in the density of the air occasioned by the peculiarities in the shapes of the undulations produced in speech, in the manner substantially as set forth; that is to say, by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting wire itself in the neighborhood of such bodies, which is the magneto method; or by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery, which is the variable resistance method. This is the process which has been patented, and it may be operated in either of the ways specified. The circuit must be kept closed to be used successfully; but this does not necessarily imply that it must be so constructed or so operated upon as to be incapable of being opened. If opened, it will fail to act for the time being, and the process will be interrupted; but there is nothing in the patent which requires it to be operated by instruments which are incapable of make and break. The *apparatus*, "as herein described," which is included in the claim, is undoubtedly one in which the electro-magnet is employed, constructed substantially as set forth in the specification. The one acting on the variable resistance mode is not described, further than to say that the vibration of the conducting wire in mercury or other liquid included in the circuit occasions undulations in the current; and no very specific directions are given as to the manner in which it must be constructed. The patent is both for the magneto and variable resistance *methods* and particularly for the magneto *apparatus* which is described or its equivalent. There is no patent for any variable resistance *apparatus*.

It is undoubtedly true that when Bell got his patent he thought the magneto method was the best. Indeed, he said in express terms he preferred it. But that does not exclude the use of the other, if it turns out to be the most desirable way of using the process under any circumstances. Both forms of apparatus operate on a closed circuit by a gradual change of intensity, and not by alternately making and breaking the circuit or by sudden and instantaneous changes, and they each require to be so adjusted as to prevent interruptions. If they break, it is a fault, and the process stops until the connection is restored.

It is again said that the claim, if given its broad construction, is virtually a claim for speech transmission by transmitting it, or in other words, for such doing of the thing as is provable by doing it. It is true Bell transmits speech by transmitting it; and that long before he did so it was conceived by scientists that it could be done by means of electricity, if the requisite electrical effect could be produced. Precisely how that subtle force operates under Bell's treatment, or what form it takes no one can tell. All we know is, that he found that by changing the intensity of a continuous current so as to make it correspond exactly to the changes in density of the air caused by sonorous vibrations, vocal and other sounds could be transmitted and heard at a distance. This is the thing to be done. Bell discovered the way of doing it. He uses electricity as the medium for that purpose just as air is used within speaking distance. In effect, he prolongs the air vibrations by the use of electricity. No one before him had found out how to use electricity with the same effect. To use it with success it must be put in a certain condition. What that condition was he was the first to discover, and with his discovery he astonished the scientific world. Professor Henry, one of the most eminent scientists of the present century, spoke of it as the greatest marvel hitherto achieved by the telegraph. The thing done by Bell was the transmitting of audible speech through long telegraph lines. Sir William Thomson on returning to his home in England in August or September, 1876, after seeing at the Centennial Exhibition in Philadelphia what Bell had done and could do by his process, spoke in this way of it to his countrymen:

> Who can but admire the hardihood of invention, which devised such a slight means to realize the mathematical conception, that if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of the current must vary continuously as nearly as may be in simple proportion to the velocity of the particle of air engaged in constituting the sound.

Surely a patent for such a discovery is not to be confined to the mere means he improvised to prove the reality of his conception.

BELL'S METHOD NOT IN REIS' APPARATUS.

We come now to consider the alleged anticipation of Philipp Reis; and here it is to be always kept in mind that the question is not whether the *apparatus*, devised by Reis to give effect to his theory, can be made with our present knowledge, to transmit speech; but whether Reis had in his time found out a way of using it successfully for that purpose, not as to the character of the apparatus, but as to the mode of treating the current of electricity on which the apparatus is to act, so as to make that current a medium for receiving vibrations of air created by the human voice in articulate speech at one place, and in effect delivering them at the ear of the listener in another place. Bell's patent is not alone for the particular apparatus that he describes, but for the process that apparatus was designed to put into use. His patent would be just as good if he had actually used the Reis apparatus in developing the process for which it was granted. That Reis knew what had to be accomplished in order to transmit speech by electricity is very apparent, for in his first paper he said:

> Since it is possible to produce anywhere or in any manner vibrations whose curves shall be the same as those of any given tone or combination of tones, we shall receive the same impression as that tone or combination of tones would have produced on us.

Bourseul also knew before Reis that this was the case, for in a communication published in the Paris journals in 1854 he said:

> When you reproduce precisely these vibrations, to wit, the vibrations made by the human voice in uttering syllables, you will reproduce precisely those syllables.

Reis discovered how to reproduce musical tones, but he did no more. He could sing through his telephone, but he could not talk. From the beginning to the end he has conceded this. In his first paper he said:

> Hitherto it has not been possible to produce the tones of human speech with a distinctness sufficient for every one. The consonants are for the most part reproduced pretty distinctly, but the vowels as yet not in an equal degree. The cause of this I will attempt to explain.

And again:

> I have succeeded in constructing an apparatus with which I am enabled to reproduce the tones of various instruments, and even to a certain extent the human voice.

None of the many writers whose papers are found in the records, claim more than this for Reis or his discovery. Although his first paper was published in 1861, Bell did not appear as a worker in the same field of scientific research until nearly 15 years afterwards. No advance had been made by the use of what Reis had contrived, nor by the use of his method, towards the great end to be accomplished. He caused his instrument to be put in the market for sale, and both he and those he employed for that purpose, took occasion to call attention to the instruments by their prospectus, catalogues and otherwise, describing what they were and what they would do. In his own prospectus, which was published in 1863 and attached to the apparatus, he said:

> Every apparatus consists of two parts, the telephone proper and the receiver. These two parts are placed at such distance from each other that the singing or toning of a musical instrument can be heard in no other way from one station to the other except through the apparatus.
>
> Both parts are connected with each other and with the battery B, like common telegraphs . . . The galvanic current goes . . . . through the copper strip to the platinum leaf on the middle of the membrane, then through the foot of the angle to the screw *b*, in whose hollow a small drop of mercury is placed . .
>
> If now sufficiently strong tones are produced in front of the sound-opening S, through the vibrations of the same, the membrane and the angular-shaped little hammer lying upon it are set in vibration; *the circuit is alternately opened and closed at every full vibration* and hereby are produced in the iron rod of the spiral at station C the same number of vibrations, and those are perceived there as tone or tone combinations.
>
> Besides the human voice there can be produced (according to my experience) just as well the tone of good organ pipes from F—*c* and those of the piano.

Albert, the mechanician employed to make the instruments, in his catalogue published in 1866, enumerates among the things he has for sale "the telephone of Reis for reproducing tones by electricity;" and in a work on electricity by Ferguson, published in London and Edinburgh, in 1867, it is said in speaking of the telephone:

> This is an instrument for telegraphing notes of the same pitch. Any noise producing a single vibration of the air, when repeated regularly a certain number of times a second, not less than 32, produces, as is well known, a musical sound. A person when singing any note causes the air to vibrate so many times per second, the number varying with the pitch of the note he sings. The higher the note the greater the number of vibrations. If we then by any means can get these notes to break a closed circuit, a note sung at one station can be reproduced, at least as far as pitch is concerned, at another. The Reis telephone, invented in 1861, accomplishes this in the following way.

It is needless to quote further from the evidence on this branch of the case. It is not contended that Reis ever succeeded in practically transmitting speech, but only that his instrument was capable of it if he had known how. He did not know how. All his experiments in that direction were failures. With the help of Bell's later discoveries in 1875, we now know why he failed.

As early as 1854 Bourseul, in his communication which has already been referred to, had said substantially that if the vibrations of air produced by the human voice in articulate speech could be reproduced by means of electricity at a distance, the speech itself would be reproduced and heard there. As a means of stimulating inquiry to that end, he called attention to the principle on which the electric telegraph was based, and suggested the application of that principle for such a purpose. He said:

> The electric telegraph is based on the following principle: An electric current passing through a metallic wire circulates through a coil around a piece of soft iron, which it converts into a magnet. The moment the current stops, this piece of iron ceases to be a magnet. This magnet takes the name of electro-magnet.
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> This magnet, the electro-magnet, can thus alternately attract or let go a movable plate, which by its movements back and forth, produces the conventional signals used in telegraphy.

Then, after referring to the mode in which speech is transmitted by the vibrations of the air, he said:

> Suppose a man speaks near a movable disc sufficiently flexible to lose none of the vibrations of the voice, and that this disc alternately makes and breaks the connection with the battery; and you may have at a distance another disc which may simultaneously execute the same vibrations.

That Reis was working all this time, from the beginning to the end of his experiments, upon the principle of the telegraph as thus suggested by Bourseul, is abundantly proved. In his first paper, after describing his cubical block apparatus, he said:

> If now tones or a combination of tones are produced in the neighborhood of the blocks, so that sufficiently powerful waves enter the opening *a*, then these sounds cause the membrane *b* to vibrate. At the first condensation the hammer-like wire *d* is pushed back; at the rarefaction it cannot follow the retreating membrane, *and the current traversing the strip remains broken*, until the membrane forced by a new condensation presses the strip (proceeding from *p*) against *d*. In this way *each sound causes a breaking and closing of the current.*

Such was the beginning and it was maintained persistently to the end, as well by Reis as by those who availed themselves of what he was doing. To this the Reis-Legat apparatus forms no exception, for in the paper describing it, Legat says:—

> The operation of the apparatus described is as follows:
>
> When at rest the galvanic circuit is closed, when the air, which is in the tube *a b* of the apparatus, Fig. 4 A, is alternately condensed and rarified by speaking into it (or by singing or introducing the tones of an instrument), a movement of a membrane closing the smaller opening of the tube is produced, corresponding to such condensation or rarefaction. The lever *c d* follows the movements of the membrane and opens and closes the galvanic circuit at *d g*, so that at each condensation of the air

in the tube the circuit is opened, and at each rarefaction the circuit is closed.

In consequence of this operation, the electro-magnet of the apparatus, Fig. 4 B, in accordance with the condensations and rarefactions of the column of air in the tube *a b*, Fig. 4 B, is correspondingly demagnatized and magnetized, and the armature of the magnet is set into vibrations like those of the membrane in the transmitting apparatus.

We have not had our attention called to a single item of evidence which tends in any way to show that Reis, or any one who wrote about him, had in his mind anything else than that the intermittent current caused by the opening and closing of the circuit could be used to do what was wanted. No one seems to have thought that there could be any other way. All recognized the fact that the minor differences in the original vibrations had not been satisfactorily reproduced, but they attributed it to the imperfect mechanism of the apparatus used, rather than to any fault in the principle on which the operation was made to depend.

It was left for Bell to discover that the failure was due not to workmanship, but to the principle which was adopted as the basis of what was to be done. He found that what he called the intermittent current, one caused by alternately opening and closing the circuit, could not be made, under any circumstances, to reproduce the delicate forms of the air vibrations caused by the human voice in articulate speech; but that the true way was to operate on an unbroken current, by increasing and diminishing its intensity. This he called a vibratory or undulatory current, not because the current was supposed to actually take that form, but because that language expressed with sufficient accuracy his idea of a current which was subjected to gradual changes of intensity, exactly analogous to the changes of density in the air occasioned by its vibrations. Such was his discovery, and it was new. Reis never thought of it and he failed to transmit speech telegraphically. Bell did, and he succeeded. Under such circumstances it is impossible to hold that what Reis did was an anticipation of the discoveries of Bell. To follow Reis is to fail, but to follow Bell is to succeed. The difference between the two is just the difference between failure and success. If Reis had kept on he might have found out the way to succeed; but he stopped and failed. Bell took up the work and carried it on to a successful issue.

OTHER ALLEGED ANTICIPATIONS OF BELL'S METHOD.

As to what is shown to have been written and done by Dr. Van der Weyde, it is only necessary to say that he copied Reis, and it was not until after Bell's success that he found out how to use a Reis instrument so as to make it transmit speech. Bell taught him what to do to accomplish that purpose.

As to James W. McDonough, we presume it will not be claimed that he is entitled to more than he asked for in his application for a patent, filed in the Patent Office, April 10th, 1876. There a circuit-breaker so adjusted as to break the connection by the vibration of the membrane is made one of the elements of his invention. The Patent Office was clearly right in holding him to have been anticipated by Reis.

The patents of Cromwell Fleetwood Varley, of London, England, one dated June 2d, 1868, and the other October 8th, 1870, were for improvements in the electric telegraph. The objects of the invention covered by the first are to cut off the disturbance arising from earth currents, and to obtain a high speed of signaling in long circuits; and the object of the second was the increase of the transmitting power by enabling more than one operator on a single wire to send more than one message to independent stations. In the specification it is said:

By my invention I superpose upon the currents used for working the ordinary telegraphs rapid undulations or waves which do not practically alter the mechanical or chemical power of the ordinary signal currents, and by new apparatus, hereinafter described, these undulations are made to produce distinct and independent audible or other signals so long as these undulations are produced, whether ordinary signal currents be flowing or not.

In short, there is nothing in any part of the specification to indicate that the patentee had in his mind undulations resulting from gradual changes of intensity exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations, which was Bell's discovery, and on which his art rests. His purpose was to superpose, that is to say, to place upon the ordinary current, another, which by the action of the make and break principle of the telegraph, would do the work he wanted.

ALLEGED ANTICIPATION BY DANIEL DRAWBAUGH.

Another alleged anticipation is that of Daniel Drawbaugh. Bell got his patent March 7, 1876, and the fortunate accident which led to his discovery occurred June 2d, 1875. Active litigation to enforce the patent rights was begun by his company on the 12th of September, 1878, with a suit in the Circuit Court of the United States for the District of Massachusetts, against Peter A. Dowd. This suit was defended by the *Western Union Telegraph Co.*, and vigorously contested. The answer was filed November 4, 1878, setting up alleged anticipation by Gray, Edison, Dolbear and others. The record fills 1,200 printed pages; but before a decision was reached the case was compromised, and a decree entered by consent. The litigation ended some time in the latter part of the year 1879. The last deposition was taken on the 19th of September in that year.

The next contested suit was brought in the same court, on the 28th of July, 1880, against *Albert Spencer* and others. An answer was filed in this case, September 6, 1880, and depositions afterwards taken, some of those in the Dowd suit being used in this by stipulation. On the 27th of June, 1881, a decision was announced by Judge LOWELL, sustaining the patent, upon which a decree was entered.

On the 14th of November, 1879, Mr. A. G. Tisdel filed in the Patent Office an application for a patent for a new and useful improvement in speaking telephones. On the 18th of November, 1879, Frank A. Klemm also filed an application for a patent, for a new and useful improvement in telephone transmitters. These inventions were transferred by assignment to Ernest Marks and Frank A. Klemm, of New York city, —— Levy, of Cincinnati, and Simon Wolf, of Washington. On the 6th of March, 1880, these parties entered into a mutual agreement, to the effect that each and all of their interests in said improvements and inventions, and the letters patent to be issued therefor, should be merged and consolidated as the common stock in a corporate body under the laws either of the State of Ohio or New York, or the general laws of the United States, relating to the formation of corporations in the District of Columbia, or in such other States and Territories as might be found necessary hereafter. This agreement was recorded in the Patent Office March 10, 1880.

On the 6th of May, 1880, Edgar W. Chellis, a merchant of Harrisburg, Pennsylvania, H. W. Jacobs, a lawyer of the same place, and Lysander Hill, a lawyer then residing in Washington, in the District of Columbia, made an arrangement with Daniel Drawbaugh, by which they were to become jointly interested with him in his alleged telephone inventions, each to have a quarter interest. Nothing was paid for this, but each of the parties was to have one quarter of anything that should be realized from the enterprise. On the 24th of May, 1880, Simon Wolf, one of the parties interested in the Klemm and Tisdel inventions, visited Harrisburg on business with Chellis in reference to telephone matters. On the 18th of May, six days before this visit, a patent was issued to Wolf and his associates upon the invention of Tisdel. While Wolf was in Harrisburg, negotiations were begun by Chellis for the transfer

of the Drawbaugh inventions, and these negotiations resulted in a conditional contract on the 22d of June, by reason of which Chellis, Jacobs, Hill and Drawbaugh went to Washington. There on the 21st of July, 1880, Drawbaugh, claiming to have invented "new and useful improvements in the transmission of vocal speech, and the apparatus to be used for those purposes, for which I am about to make application for letters patent of the United States" assigned to Klemm, Marx, Wolf and Levy, the full and exclusive right to the said inventions as fully set forth and described "in the specifications prepared and executed by me, dated 21st July, 1880, preparatory to obtaining Letters Patent of the United States therefor." He at the same time, and by the same instrument, authorized and requested the Commissioner of Patents to issue the patent to his assignees, each as assignee of one-quarter part. The specification referred to in the assignment has not been put in evidence in any of the cases. In the course of taking the testimony it was called for by the Bell company, but the counsel for the opposite party declined to produce either the original or a copy from the Patent Office. The assignment was recorded in the Patent Office July 22nd, 1880, and in the official Digest of Assignments the following notice appears:

About to make application. Specification dated July 21st, 1880.

On the morning of July 22nd, 1880, the following article appeared in the *Cincinnati Commercial*, a newspaper printed at Cincinnati, Ohio:

TELEPHONE COMBINATION.

Special to the *Cincinnati Commercial*.

WASHINGTON, D. C., July 21.

An application for a patent was filed to-day, that in consequence of its vastness of interest, as well as wealth of prospect, renders it a subject of national interest. A company of leading business men has been formed, that has bought up all the telephone patents antedating those now in use, and known as the Bell, Gray, and Edison patents. The company is composed of leading business men from all parts of the country, Cincinnati being largely represented and interested. The cash capital of the company is $5,000,000, with headquarters in New York, and in about 60 days they will open up the telephone, which will certainly result in the driving out of all telephones in the market, save the ones they hold, or else in compelling the Gray, Bell and Edison lines to pay the new company a munificent royalty. It appears from the testimony now on file and in the possession of the new company, which is conclusive and exhaustive, that the inventor of the telephone is a poor mechanic, living near Harrisburg, Pa., named Daniel Drawbaugh. Owing to his poverty, he was unable to push his patent on the market. The new company have secured and are sole possessors of this invention, antedating those now in use. They are also owners of four patents for telephones issued to Mr. Klemm, of New York. A large number of capitalists were here to-day to see the filing of the application, and they assert, with a positiveness that is almost convincing, that it will not be long till they have entire charge of the telephones, not only in this country but in the world, and that they will be able to establish lines by which messages can be transmitted for almost a song.

Mr. Lipman Levy, of the law firm of Moulton, Johnson & Levy, of Cincinnati, was here to-day in the interest of the Cincinnati parties, who, as already stated, are among the most prominent financial men of our city.

Afterwards, on the 23rd of August, 1880, the following appeared in the *Journal of Commerce*, a newspaper printed in the City of New York:

A New Telephone Company.—A company has recently been formed in this city with a capital of $5,000,000 for the purpose of manufacturing telephones. The company is to be known as the People's Telephone Company, and a number of leading capitalists in this city and Cincinnati are interested in it. The telephones are to be manufactured under the patents of Frank A. Klemm and Abner G. Tisdel, and the application for patents of Daniel Drawbaugh, of Eberly's Mills, Cumberland county, Pa., filed July 21st, 1880. It is claimed by those interested in the new enterprise that Drawbaugh is really the inventor of the telephone, and had completed one years before Professor Bell or any one else had manufactured one. He was, however, in very humble circumstances, and his neighbors who knew of his experiments looked upon him as a harmless lunatic. He continued improving his original telephone, and it is claimed that the one which the new company proposes to furnish is superior to any now in use. The company has fitted up a factory in Brooklyn, and in three months will be prepared to supply 1,000 of the new telephones. As soon as operations are actively commenced, it is expected that legal proceedings will be begun against the new company by the Gold and Stock Telegraph Company, which holds most of the existing patents, and a long and interesting legal fight is anticipated.

On the 30th of August, 1880, the People's Telephone Co. was incorporated under the general laws of New York, with an authorized capital stock of $5,000,000, for manufacturing, constructing, owning, furnishing, letting and selling telephones and the apparatus used therewith under the inventions and patents of Abner G. Tisdel, Frank A. Klemm, Daniel Drawbaugh, and other inventions and patents which may hereafter be assigned to that company. On the 4th of September, 1880, Klemm, Loth, Marx and Wolf, in consideration of $4,999,550, represented by 99,991 shares of stock, assigned and transferred to that company all their interests in the Klemm, Tisdel and Drawbaugh inventions, those of Drawbaugh being described as "inventions in telephones made by Daniel Drawbaugh, of Eberly's Mills, Cumberland county, Pennsylvania, for which applications for patents were made on or about the 21st of July, 1880, and which were assigned to us on the 31st of July, 1880, as more particularly appears in the deed of assignment, recorded in the United States Patent Office." For the assignment from Drawbaugh to Klemm, Marx, Loth and Wolf, $20,000 was paid in money to Chellis, Jacobs and Hill, and they were allowed to have a certain amount of the stock of the proposed corporation then formed. What amount they actually got, Chellis, who was sworn as a witness in the case, declined to state, but he admitted it was large.

At this time and in this way, the attention of the general public was called, for the first time, to the fact that Drawbaugh claimed to have anticipated Bell in the discovery of the telephone. Bell's success had been proclaimed more than four years before, at the Centennial Exhibition in Philadelphia. In the meantime inventions in aid of his discovery had been multiplied. According to the testimony of Park Benjamin, more than 100 patents had then been issued and indexed under the word "telephone," and numerous interferences had been declared and considered by the Patent Office. Gray, Edison, Dolbear and others, had either claimed for themselves, or others had claimed for them, priority of invention and discovery, and Bell had thus far been sustained as against them all. Blake had perfected his microphone apparatus, and Bell's patent had become a great commercial success. The People's company either began, or threatened to begin operations under its charter, and on the 20th of October, 1880, the Bell company brought suit against it in the Circuit Court of the United States for the Southern District of New York, to prevent any infringement of the Bell patent. In the bill it was alleged that—

telephone exchanges now exist in more than 275 towns and cities of the United States, and in every state thereof, and exist in substantially every city having more than 15,000 inhabitants, and in many smaller places. . . . . . That there are now in use more than 100,000 electric speaking telephones, licensed by and paying royalty to the Bell company; that the owners of the Bell patents, and those who now are or heretofore have been licensees of them, have devoted great time and attention and large sums of money to the development of the telephone and the introduction thereof into extensive use, and to the proper construction of the most suitable telephone lines and systems, and telephonic appliances, and have constructed many thousand miles of telephone lines for use with telephones owned by the Bell company and licensed by it for such use; and nothing which the defendants, or F. A. Klemm, A. G. Tisdel or Daniel Drawbaugh have done, has contributed in any substantial way to the development of the telephone or the introduction thereof into use.

The bill then avers that Klemm, Marx, Levy and Wolf, having become the owners of these inventions, and having heard that Daniel Drawbaugh claimed that—

he had made some experiments relating to electric speaking

telephones (which experiments, if made, were incomplete, imperfect, unfruitful and long before abandoned), entered into an arrangement with him to set up and claim that he was the first inventor of the electric speaking telephone, and to make application for a patent therefor; and that thereafter alleging and pretending that said Drawbaugh was the original and first inventor of the electric speaking telephone, and that electric speaking telephones had not before such application been in public use or on sale for more than two years with the knowledge and consent of Drawbaugh, did on or about the 21st of July, 1880, induce him to make and cause to be filed in the Patent Office of the United States an application for a patent, to issue to them as the assignees of the said Drawbaugh as the first and original inventor of the electric speaking telephone.

It was then further alleged that if Drawbaugh had ever made his pretended inventions, they had not been, by him or any one claiming under him, introduced into public use, and "that knowledge thereof has been witheld from your orators and the public, except so far as they have been disclosed within the three months last past by certain newspaper publications."

To this bill the People's company filed an answer in December 1880 or January 1881. The record does not show the precise date. In this answer it was said that Drawbaugh was the original and first inventor and discoverer of the art of communicating articulate speech between distant places by voltaic and magneto-electricity, and that long prior to the alleged invention by Bell, Gray and Edison, he then and now residing at Eberly's Mills constructed an apparatus which was a practical working electric speaking telephone, at said Eberly's Mills, and exhibited the same in successful operation to a great number of other persons residing in his vicinity and elsewhere; and that his telephones as then constructed and operated contained all the material and substantial parts and inventions patented in the patents of Bell, and also other important and valuable inventions in electric and magneto telephones, and were actually used for transmitting articulate vocal sounds and speech between distant points by means of electric currents; that he had the original instrument which he used and had exhibited to many others long prior to the said alleged inventions of Bell or either of them; that they are still in existence and capable of successful and practical use, and are identified by a large number of persons who personally witnessed their practical operation and use in the years 1870, 1871, 1872, 1873 and 1874 and several years prior and subsequent thereto; that certainly more than fifty and probably not less than one hundred persons, or even more were cognizant of said Drawbaugh's invention and use of said telephone, and of his claiming to be the original and first inventor thereof prior to the alleged inventions of said Bell or either of them; that said Drawbaugh for more than ten years prior to the year 1880 was miserably poor, in debt, with a large and helpless family dependent upon his daily labor, and was from that cause alone utterly unable to patent his invention or caveat it, or manufacture and introduce it on the market; that said Drawbaugh never abandoned the said invention nor acknowledged the claim of any other person or persons thereto, but always persisted in his claims and intended to patent it as soon as he could procure the necessary means therefor. That said Drawbaugh never acquiesced in the public use of said Bell, Gray, Edison, Blake or other telephones, nor in the claims of the alleged inventors nor gave his consent to such use.

It is then said that Drawbaugh, after finding by experiment that his invention was capable of successful working, conceived that its range and capacity for usefulness to the public might be greatly enlarged, and that many improvements of great value might be made and added to it, which without departing from its principle, might increase its value to himself and to the public; and therefore set himself at work to discover and invent such improvements; that he discovered and invented some such improvements prior to any alleged invention by the said Bell; and then, notwithstanding his embarrassed and impoverished pecuniary condition, and his utter want of proper mechanical tools, materials and appliances to conduct such work, he labored with all reasonable diligence to perfect and adapt his said improvements, and did finally, in due exercise of such reasonable diligence, perfect and adapt the same; and that, in so far as the said Bell has incorporated such improvements in his said two patents, or either of them, he, the said Bell, has surreptitiously and unjustly obtained a patent or patents for that which was in fact first invented by said Drawbaugh, who was using reasonable diligence in perfecting and adapting the same; and therefore, the patent or patents of the said Bell therefor is, or are, invalid and void.

It is then said that—

the defendants in good faith, and relying upon his legal rights, caused application to be made and filed in the Patent Office for the invention of the said Daniel Drawbaugh, with the intention of procuring interference proceedings to be instituted in accordance with the statute, against the patents of said Bell, and the pending applications of said Gray, Edison and others, in order that said Drawbaugh might be adjudged by the Commissioner of Patents to be the original and first inventor of the electric speaking telephone, and might be adjudged entitled to receive a patent or patents therefor.

The People's company began taking depositions on the 19th of April, 1881, but Drawbaugh himself did not appear as a witness until December 7th, 1881. After that time others were examined, and when the proofs were closed, between three and four hundred witnesses had been produced whose testimony was taken and put into the record to establish the priority of Drawbaugh's invention. This testimony, as is now claimed, shows the story of that invention to have been as follows:

Early conception and experiments with a continuous current, 1862 and 1866 and 1867.
Tea-cup transmitter and receiver, 1866 and 1867.
Tumbler, tea-cup and mustard can, F and D, 1867 and 1869.
Improvement on B, namely, C, 1869 and 1870.
Further improvements on C and the more perfect magneto-instrument I, 1870 and 1871.
Mouth-piece changed to centre and adjusting-screw inserted (exhibit A), 1874.
D and E, perfectly adjusted and finished magneto-instruments, January and February, 1875.
L, M, G and O, February 1875 to August, 1876.
H, August, 1876.
J, N and P, 1878.

This statement of the Drawbaugh claim we have quoted from the brief of counsel appearing in his behalf, and his success in the litigation has been based, as we understand it, both in the answer and in the argument, on the truth or falsehood of what is thus set forth.

The letters F and D, &c., in the statement, refer to exhibits in the case, being certain instruments claimed to have been made and used by Drawbaugh in the progress of his work, and preserved until now. The original teacup instrument was not produced, but Drawbaugh gave in his deposition what he said was a drawing showing how it had been constructed. F, B, C, D, I and A, were neither of them in a condition for use when they were put in evidence, and none of the witnesses except Drawbaugh could tell how they were originally constructed, or what the process was by which sound was transmitted when they were used. All that any of the witnesses could say on that subject was that they had used one or more of the different instruments at Drawbaugh's shop, and heard sounds and sometimes words spoken to them, and that Drawbaugh told them the sound was carried on the wire by electricity. There was nothing whatever produced in print or in writing on the subject, nor even a memorandum or drawing of any kind, and there is nothing in the testimony to show that Drawbaugh ever told any one how his earlier instruments were made, or what his process was, until he was called as a witness in December, 1881, and explained it in his testimony. This was nearly twenty years, according to the present claim, after he had begun his experiments, nearly seven years after he had made and used D and G,

perfectly adjusted and finished magneto instruments, more than five years after L, M, G, O and H, had been constructed and connected in his shop, if his story is true. It was also nearly six years after the date of Bell's patent, more than five years after the success of his discovery had been proclaimed at the Centennial Exhibition in Philadelphia, four years after his invention had gone into public use, three years after it had become an established success, and two years after he had brought the first suit for the establishment of his right against Dowd, who represented the Western Union Telegraph Company, to a successful termination.

THE CONDUCT OF DRAWBAUGH CONSIDERED.

Under these circumstances it becomes important to consider the conduct of Drawbaugh in reference to his alleged invention during his twenty years of eventful history, as connected with the discovery and use of the telephone. If his present claim is true his experiments began almost as far back as those of Reis, and he had in his shop at Eberly's Mills, within three miles of Harrisburg, telephones that were substantially perfect months before Bell (on the 2nd of June) 1875. got the clue to his subsequent discovery. It is conceded that D and E, claimed to have been made in February, 1875, are substantially as good magneto instruments as any Bell had used before December, 1881 ; and L, M, G, O and H, all of which were constructed, it is claimed, between February, 1875, and August, 1876, are as good, or nearly as good microphones as those of Blake, which were not invented until 1878. This is the theory of Drawbaugh's defense, as set forth in the answer and in the argument, and by it his case must stand or fall.

The claim is that the discovery of the process was complete, and that perfect telephones had been made and were in a condition for actual use a year and more before Bell got his patent.

Drawbaugh was, when he gave his deposition, 54 years of age, and had lived all his life at or near Eberly's Mills, a small village near Harrisburg. He was a skillful and ingenious mechanic, and if he made D and E, and the instruments which came after them at the time it is said he did, he had good tools and good material in 1875 and 1876, and was capable of doing the best of work. He was also somewhat of an inventor, and had some knowledge of electricity. According to the testimony he was an enthusiast on the subject of his talking machine, and showed it freely to his neighbors and people from the country, whenever they visited his shop.

The Centennial Exhibition was opened in Philadelphia, in May, 1876. Drawbaugh visited it on the 17th of October, 1876, remaining four or five days. Before he went he had heard, as he says, that some one besides himself had invented a speaking telephone, which he had the impression was on exhibition there. If what he now claims is true, he had then on hand in his shop, exhibits D, E, L, M, G, O, and H, all of them good instruments of their kind and capable of transmitting speech, and some of them but just finished. Bell's apparatus had been exhibited to the Board of Judges in June before, and had attracted marked attention. The matter was much discussed in the public press, and yet it never seems to have occurred to Drawbaugh to take any of his telephones with him when he went, although they were small in size, and some or all of them could have been carried without serious inconvenience. When giving his testimony he was examined in chief as to that visit, and this is what he said on the subject of telephones :

Q. Did you attend the Centennial Exhibition at Philadelphia in 1876? *A*. Yes sir, I did.

Q. Can you give the date on which you went there? *A*. I can by reference to a book. It was October, 1876. The 17th was a day on which I dated a letter from Philadelphia when I was there on that visit.

Q. How long did you visit there last? *A*. About four or five days, to the best of my recollection.

Q. Who went with you on that visit? *A*. Mr. George Leonard.

Q. Was that the only visit to the Centennial Exhibition that you made? *A*. Yes sir ; it was.

Q. At the time that you went there, or before that time, had you heard that somebody else besides yourself had invented a speaking telephone or a telephone? *A*. Yes, sir ; some time before that. I don't remember how long, but not a great while.

Q. When you went there, did you suppose it would be on exhibition there? *A*. I don't remember whether I had heard that it was on exhibition or not, but I got the impression some way that it was on exhibition.

Q. While you were there at the Centennial did you see any telephones or make an effort to see any there? *A*. Yes, sir ; I made an effort and seen an instrument called a telephone and supposed it to be the instrument spoken of ; the one of which I had heard. I was looking and had made some inquiry, and was directed or came to a portion of the building where I saw on a counter some man's telephone, the name I don't remember. At that time or several times that I called, there was no one there to attend to it. I spoke to another party that had something else on exhibition, I don't recollect what it was, just near by, and I asked him whether there was any one there to attend or show the instruments. I was informed then there was no one there to show them.

Q. If you remember, please state what kind of an instrument it was that you saw there, and state what information you were able to obtain there regarding it and its mode of operation? *A*. There was a number of instruments placed on to a raised portion, something like a shelf ; that is, it resembled something like pigeon-holes, a box open in front, and each instrument at the back of it had an electro-magnet The number of instruments I don't remember. I don't remember of counting them. If I am not mistaken there may have been a dozen or more. Perhaps some were larger than others. I can't give you a much better description than that. I couldn't get any information about them. This attendant made some remarks about the instruments, but he didn't understand them and couldn't explain them. I was several feet from where the instruments were. They were on a raised place like a shelf, just about high enough for a man to speak into. That is the way it looked to me. I didn't go in behind the counter to examine them.

Q. Did you see any circulars lying around there referring to these instruments or any advertisements of them? *A*. I don't remember about that. It may have been.

Q. What was your impression as to the character of the instruments when you finally left them? *A*. I was impressed with the idea that they were instruments to telegraph by sounds, a certain sound to represent a certain letter of the alphabet. I am not certain how I got the idea, or whether any person told me that at the time, but that is the idea that I had.

Q. Do you know whether that was Gray's harmonic telegraph that you saw there or not? *A*. It didn't say "telegraph." I am confident it was called telephone. I didn't see the working parts of the interior except the electro-magnets. I took the name of the man and his address on a piece of paper and put it in my pocket, but I don't know what became of it. I don't know whether it was Gray's harmonic telegraph or not.

Q. Did you see any tuning-forks about it? *A*. I did not.

That was all he did during his entire visit to ascertain whether any one besides himself had actually entered upon this new and interesting field of invention and discovery. He spoke to no one about what he had done himself. He made no special effort to find out whether that which was on exhibition was in any respect like what he had at home ; neither did he when he got home, as far as the record shows, say anything to his neighbors or visiting friends about what he had seen or heard. He had apparently lost all interest in talking machines.

Not so, however, with his other inventions. The testimony shows that during the early part of 1876 he was much occupied in building an electric clock which he thought of exhibiting at the Centennial. This he did not do, however, but several days before he went to Philadelphia, or soon after, Rufus E. Shapley, a jeweler of Mechanicsburg, went on his suggestion to Eberly's Mills to look at the clock which he had made. Soon after that the clock was taken to Shapley's store in Mechanicsburg, and on the 8th of November, 1876, Drawbaugh, by an instrument in writing, transferred to Shapley a one-half interest "In the clock I am getting up, the said Shapley to pay for patenting the same." Shapley had then $2,000 in money, which Drawbaugh was anxious to have him invest in this business. The clock was taken by him to his shop so that it might be examined with that end in view, if it should prove to be useful. Some time after-

wards it was taken back to Eberly's Mills, where it remained until April 1st, 1878, or thereabouts, when a clock company was formed, and this clock, or another one substantially like it, was taken about the country for exhibition. For this, Drawbaugh was paid $500 and an interest in the profits.

On the 20th of September, 1878, he applied for a patent for improvements in batteries for electrical clocks. The patent was issued January 14th, 1879, to the members of that clock company. The enterprise does not seem to have been productive of any very great success.

In November or December, 1878, while this clock was on exhibition, Drawbaugh was introduced to Edgar W. Chellis. He had with him at the time a wooden model of a faucet that he wanted Chellis and another man to take a one-third interest in. An arrangement was made by which Chellis got a two-thirds interest, he paying $250 for it January 7th, 1879. On the 14th of the same month, Drawbaugh filed in the Patent Office an application for an improvement in rotary measuring faucets. After this applicat.on an interference was declared, March 27th, 1879, between Drawbaugh and David A. Hauck, who had filed an application. In his preliminary statement in this interference, Drawbaugh said he had conceived the idea of his faucet in the fall of 1869, and made a working model in 1877, and the Patent Office model was not completed until about the 1st of November, 1878. The case was closely contested and finally decided in favor of Drawbaugh, January 15th, 1880. The patent was granted to him and Chellis July 6th of the same year. In this contest, Jacobs and Hill, who afterwards became interested in the telephone claim, appeared as the counsel for Drawbaugh.

On the 2d of July, 1879, Drawbaugh filed another application in the Patent Office for an improvement in water motors. Chellis was to have in this also a two-third interest. On this application a patent was issued March 16, 1880.

DRAWBAUGH'S CONDUCT INCONSISTENT WITH HIS CLAIMS.

It is impossible to believe if Drawbaugh had in his shop, when he reached home from the Centennial, exhibits D, E, L, M, G, O and H, or even D and E alone, that he would have set himself to work in the first instance in developing the clock enterprise or perfecting his former conception of the measuring faucet, instead of calling attention to his great discovery of the telephone, which he was in danger of losing by a patent which had been issued to another, and which he could not but have known was even then attracting the greatest attention. In this connection it must be kept in mind that the theory of the defense, as stated in their answer is, that, Drawbaugh had at that time fully perfected his invention, and that while at first "he conceived that its range and capacity for usefulness to the public might be very greatly enlarged," he had before the date of Bell's patent, "notwithstanding his impoverished and embarrassed pecuniary condition and his utter want of proper mechanical tools," finally perfected his work. His conduct, therefore, is to be judged, not as of one who was still in the midst of his experiments and doubtful as to the results, but as of one who had arrived at the end, and completed his success. No man of his intelligence, with or without the enthusiasm on the subject which it is said he possessed, could remain silent under such circumstances.

As we have read the testimony, it is not even pretended that he took any of these instruments outside of his own village until May, 1878, when, as is claimed, he showed one to his friend Stees, in Harrisburg, whom he had known for years, who was the first to use, and in fact was then using, a Bell telephone upon a private line of his own between his office and his shops. This produced no results; and when afterwards, in January, 1879, Chellis was told that Drawbaugh had a phonograph and a telephone that he had invented, he gave it no attention, because, to use his own language, "I was interested in the faucet and motor business and wished to push them, and I did not think we could do much with a telephone, as Bell had a patent and I did not know that he could antedate it."

Again, when speaking of a conversation he had with Drawbaugh he said, "I advised him to drop the telephone, as he could not antedate Bell. He said he didn't know about that; that he had been working on it a good while. It was his way of expressing himself when I would say "You can't antedate Bell." He would say, "I don't know about that; I have been working at it a good while."

This, it must be remembered was in 1879, after the telephone had become a success, and after it had been a year or more in use in Harrisburg where Chellis lived. It is impossible to believe that either Chellis or Drawbaugh was ignorant of the approximate time of Bell's invention, which had been the subject of frequent newspaper comment from the time of its exhibition at the Centennial. The subject was often referred to in the Harrisburg and Mechanicsburg papers, and it is not for a moment to be supposed that all these various articles escaped their attention. Under such circumstances, if it were true that Drawbaugh had made his D and E as is now claimed, in February 1875, he certainly would have said so, and he would not have contented himself with so doubting an answer to Chellis' suggestion of his inability to antedate Bell, as that which Chellis now says he gave.

Another important fact in this connection is one which is proved by the testimony of Andrew R. Keifer, who from 1863 had been division telegraph operator having charge of the middle division of the Pennsylvania railroad, and resided in Harrisburg from 1863 to the winter of 1881. He was a member of an electric firm in that place, engaged in the manufacture of burglar alarms, instruments for the signal bureau, etc. He had also since 1876 kept a place for the sale of electrical supplies. He had known Drawbaugh since 1876, and probably before. Drawbaugh met him on different occasions in the course of their acquaintance and talked with him on electrical matters. In the course of their acquaintance, Drawbaugh showed him an electrical fire-alarm apparatus, and the working of his electrical clock, but the subject of telephone was never alluded to between them until the summer of 1881 when this occurred (we quote from the deposition of Keifer).

> In the summer of 1881 I took my wife out for a drive and went over to see his works, never having seen them, and having promised him to come and see him some time; my wife not caring about going to the shop remained in the carriage, and I went through alone with Mr. Drawbaugh. He showed me through the shops and introduced me to Mr. Chellis, and showed me parts of the water-motor and some other things of his getting up. On account of my wife being in the carriage alone I did not stay long. As I stepped into, or was just in the carriage, Mr. Drawbaugh said: "I forgot to show you my telephone! I did not get out again to go and see it, and I drove away without seeing it, expecting to see it again, but I have never got over to the shop since.

This was after the suit of the Bell company against the People's company was begun, and of course after the matter got into the hands of Chellis and his associates. It is no answer to the criticism of Drawbaugh's conduct in this particular to say, as was said in the argument, that one reason why he did not speak or apply to every man with whom he had a personal acquaintance was that he was ridiculed by his neighbors; that his invention was considered a humbug by them and of no commercial value. Bell's success was proclaimed in the Harrisburg *Patriot* as early as February 26, 1877, and the age of ridicule was then past. If Drawbaugh had at that time in his shop the machines it is now claimed were there, complete as they now are, in August, 1876, and most of them before, there cannot be a doubt that he would have taken them to some place where they could be tried, and show that they

would do what he had all along claimed for them. All he had to do at any time after he came back from the Centennial was to take any pair of his little instruments to his friends at Harrisburg, attach them to a line wire and show what he had. They were men who could appreciate the telephone and help him, if it was, as he now says it was, a success. It would certainly have been easier then, within two years of the time the first of them was made, and within a year of the date of Bell's patent, to show that he antedated Bell, than it was three years afterwards when he was brought into the controversy through the instrumentality of his associates, not, as must be evident to all, to get a patent for himself, but to defeat that of Bell.

In this connection it is specially significant that the application which it was claimed was made for a patent on the 21st of July, 1880, and the specification of his invention which was then written out, has been purposely and designedly kept out of the case, although their production was demanded. They were written before this suit was begun, and it is impossible to believe that they would have been withheld, at least upon the call of the opposite party, if they were in all respects consistent with the subsequent development of the case. The excuse given by counsel at the time, that they were in the secret archives of the Patent Office, and if produced and published in this case would possibly invite the filing of contesting applications and result in an interference and additional litigation, besides unnecessarily prolonging the taking of testimony and increasing the expenses, we cannot accept as satisfactory, in view of the fact that in the answer, it was said that one object of filing the application "was to procure interference proceedings to be instituted against the patent of Bell, in order that Drawbaugh might be adjudged by the Commissioner to be, as he rightfully is, the original and first inventor."

We have not overlooked the depositions that have been taken in such large numbers to show that Drawbaugh was successful with F, B, C, I and A, before D and E were made. They have been studied with care, and if they constitute all the testimony in the case it would be more difficult to reach the conclusion that Drawbaugh's claim is not maintained. But in our opinion their effect has been completely overcome by the conduct of Drawbaugh, about which there is no dispute. From the time of his visit to the Centennial until he was put forward by the promoters of the People's company, nearly four years afterwards, to contest the claim of Bell, he was silent, so far as the general public were concerned; while if he had really done what these witnesses say he did, he would certainly have spoken. There is hardly a single act of his connected with his present claim, from the time he heard, before going to Philadelphia, that some one else had invented a telephone which was on exhibition at the Centennial, that is not entirely inconsistent with the idea of a complete discovery or invention by himself which could be put to any practical use.

It is not pretended that what he did was done in private. He had influential friends, with ample pecuniary resources to help him in bringing out his inventions when they promised success. He easily got aid for his clock and for his faucet. The news of Bell's invention spread rapidly, and it took but a few months to demonstrate to the whole world that he had achieved a brilliant success. No one can believe that the public would be kept in ignorance of the invention until four years afterwards, when a special despatch from Washington to the *Cincinnati Commercial* announced a telephone combination to have entire charge of the telephone in this country.

DRAWBAUGH FAILS TO REPRODUCE HIS ALLEGED RESULTS.

But there is another fact in this case equally striking. As has already been seen, F, D, C, and I were in no condition for use when they were produced and put in evidence. They were mere remains. No one but Drawbaugh himself could state how they were made or how they were to be used. He undertook to reproduce some of them, especially F and G. This was in the latter part of 1881, while the testimony was being taken. The Bell company proposed that they should be tried, to see if they would do what the witnesses said had been done with the originals, which the remains show must have been exceedingly primitive in their character. The testimony also shows that when they were originally used, by or in the presence of the witnesses, no particular care was taken in their adjustment. They were lying around in the shop or placed upon shelves. Some say that when the experiments were made they were held in the hands or allowed to stand on a table In order to reach satisfactory results Drawbaugh himself said in his deposition :

> I had persons in the cellar reading printed matter, some advertisement or something, and I could hear the words that were read; and at other times I would go down into the cellar and read something and come up, and they would repeat the words to me that I had read.

The proposition of the Bell company was accepted, and the reproductions were tried in March, 1882, under the most favorable circumstances. It is substantially conceded that the trial was a failure. Occasionally a sound was heard and sometimes a word, but it would not transmit sentences. At the time of these experiments, F, which was the transmitter, was placed on a table as Drawbaugh said it was originally.

Two years afterwards other reproductions were presented, differently constructed and used in a different way. Those would talk, but they were neither the same nor used in the same way as the originals. To our minds, the result of the experiment conclusively shows that the original instrument could not have been of a construction similar to the reproductions, and that what they had done was produced by some other means.

We do not doubt that Drawbaugh may have conceived the idea that speech could be transmitted to a distance by means of electricity, and have experimented upon that subject. But to hold that he discovered the art of doing it before Bell did, would be to construe testimony without regard to the ordinary laws that govern human conduct. Without pursuing the subject further we decide that the Drawbaugh defense has not been made out.

THE ALLEGED FRAUD IN THE PATENT OFFICE.

Another objection to Bell's patents put forth in the oral argument of Mr. Hill, and in the printed brief signed by him, and in that signed by Mr. Dixon is, that the application as originally filed in the Patent Office, did not contain his present fourth claim or any description of the variable resistance method, and that all which now appears in the specification on that subject, including the fourth claim, was surreptitiously interpolated afterwards. Bell's application was filed February 14th, 1876, and afterwards, during the same day, Elisha Gray filed a caveat in which he claimed as his invention "the art of the transmission of vocal or other sounds or conversation telegraphically, through an electric circuit," and in his specification described the variable resistance method. The precise charge now made in the printed brief of Mr. Hill is—

> That Mr. Bell's attorneys had an underground railroad in operation between their office and Examiner Wilber's room in the Patent Office, by which they were enabled to have unlawful and guilty knowledge of Gray's papers, as soon as they were filed in the Patent Office; and that an important invention and a claim therefor were bodily interpolated into Bell's specification between February 14th, 1876, and February 19th, 1876, by Pollok, in consequence of the guilty knowledge which the latter already had of the contents of Gray's caveat before the declaration of interference with Gray on February 19th.

So grave a charge, made in so formal a manner, is entitled to consideration. It involves the professional integrity and moral character of eminent attorneys, and

requires us to find from the evidence, that after Bell swore to his application on the 20th of January, 1876, and after the application thus sworn to had been formally filed in the Patent Office, an examiner who got knowledge of the Gray caveat put in afterwards, disclosed its contents to Bell's attorneys, and they were then allowed to withdraw the application, change it so as to include Gray's variable resistance method, over Bell's signature and over the jurat, and then to restore it to the files thus materially altered, as if it were the original, and all this between February 14 and February 19. Although much stress was laid in the argument on the fact that what purported to be a certified copy of the specification of Bell, as found in the file-wrapper and contents printed in the Dowd case, differed materially from the patent, the occasion of these differences has been explained in the most satisfactory manner.

We entertain no doubt whatever that the specification as now found in the patent is precisely the same as that on which the order to issue was made. If any alterations were made they were all done before February 19, and the fair copy which is now found on the files of the Office is precisely as it was when the order for the patent was granted; not a shadow of suspicion can rest on any one.

All that remains, therefore, on which to rest this serious charge, is that in a paper handed by Bell to George Brown, of Toronto, describing his invention, and which was intended to be used in England to secure a British patent, there is now claimed to be an interpolation which in the American application is not to be found. It is but right to say that during the whole course of the protracted litigation about the Bell patent, no argument was ever presented based on this discrepancy until the brief of Mr. Hill was filed in this Court on the 18th of January 1887, six days before the argument on these appeals was begun. So far as we are advised, nothing has ever before occurred in the cases that seemed to make it necessary to prove when the variable resistance method, or the fourth claim, was put into the American application, or why it was left out of the paper handed to Brown. It seems always to have been assumed, until the cases got here, that because it was in the American patent it was rightfully there. Certainly there is nothing in the pleadings in any of the cases to direct attention to the materiality of this fact. A comparison of the paper handed to Brown with the American application shows that they differ in more than thirty different places, besides those which relate to the variable resistance method and the fourth claim. The differences are generally in forms of expression, this indicating that one was written after the other, and evidently for the purpose of securing greater accuracy. The paper handed Brown was merely a rough draft and not a fair copy, for the record shows that it bears on its face the evidence of numerous erasures and interlineations. Bell says in his testimony that he began writing this specification in October 1875, and wrote and rewrote it a number of times, and finally adopted that mode of expression which seemed to him best to explain the invention and the relation which one portion bore to another. He visited Brown in Canada in September and again in December 1875. An arrangement was made between them on the 29th of December, at the last interview, by which Brown was to interest himself in getting out the British patent. Other inventions besides the telephone were included in the contract entered into for that purpose. Bell returned to Boston on the first of January, and immediately set himself to work to complete his specification. It was taken to Washington by Mr. Hubbard, about the 10th of that month, and delivered to Pollok & Bailey, his attorneys. It was then examined by his attorneys and found correct, and a fair copy made, and then returned on the 18th to Bell, for his signature. It was signed and sworn to in Suffolk county, on January 20th, and immediately returned to the attorneys. Afterwards Mr. Pollok met Bell in New York, and it was again gone over with care by the two together. No change whatever was made in it at that time and Mr. Pollok took it back with him to Washington.

On the 25th of January, 1876, Bell met Brown, who was then on his way to England, in New York. It is now assumed that the papers which Brown took to England was handed to him then; and because the variable resistance method in the fourth claim was not in it, it is argued that it could not have been in the American specification at that time. But no one has said when the paper was actually handed to Brown. Bell says he cannot tell, but it must have been after he made his contract with Brown on the 29th of December. As the American specification was signed and sworn to five days before the interview with Brown on the 25th of January, and the paper of Brown differs from it in so many particulars besides that now in question, it would seem to be clear that the paper was a copy of some former draft that Bell had made and possibly taken to Canada in December, not that which was perfected afterwards. As the specification which had been prepared and sworn to, was a fair copy without erasure or interlineation, the fact that the paper handed to Brown was not a fair copy would imply that it was not intended to be an exact transcript of the other.

At any rate, the bare fact that the differences exist under such circumstances is not sufficient to brand Bell and his attorneys and the officers of the Patent Office with that infamy which the charges made against them involves. We therefore have no hesitation in rejecting the argument. The variable resistance method is introduced only as showing another mode of creating electrical undulations, and that Bell had had his mind upon such a method is conclusively established by a letter which he addressed to Mr. Hubbard on the 4th of May, 1875, and which is in the Dowd record, introduced into the Overland record by stipulation. Its insertion in his final draft of his specification is another proof of the care with which the work had been done.

INCORPORATION OF THE BELL COMPANY.

In the case of the Clay Commercial Co. objection was made to the sufficiency of the proof of the incorporation of the American Bell Telephone Co. The first point is as to the act incorporating the American Bell Co., which authorized certain persons therein named to form a corporation; and second the certificate of the Secretary of the Commonwealth, in the form required by Section 111, Chapter 224, that certain persons, among whom were the members of this company, under the name of The American Bell Telephone Co., were legally organized. This section made such a certificate conclusive evidence of the existence of a corporation organized under that act. The authority granted by the special act to the persons named to organize as a corporation in this way, gave them the authority to select a corporate name and also made the statutory certificate conclusive evidence. The objections to the proof of title are not, in our opinion, well taken. We do not think it necessary to add to the length of this opinion by referring to the testimony upon that point.

THE SECOND BELL PATENT.

This disposes of all the cases so far as the patent of March 7th, 1876, is concerned. It remains now to consider only the other patent. It received but little attention by counsel or court in either of the cases below. In the Dolbear case it was by consent excluded from the decree.

In the case of the Clay Commercial Co. it was alleged in the answer that substantial and material parts of the things described and claimed were described and claimed in a prior British patent taken out December 9th, 1876

and inasmuch as the foreign patent does not bear the same date, if the American patent is not limited it is void. This point has not been pressed in the argument. In our opinion it has been settled by the decisions of this court in *O'Reilly* v. *Morse* and in *Siemens* v. *Sellers* at the present term, that the effect is not to render it invalid if it is for the same invention, but only to limit its term. The patent in itself is for the mechanical structure of an electric telephone, to be used with the electrical action on which the first patent rests. The *third* claim is for the use, in such instrument, of a diaphagm made of a plate of iron or steel, or other material capable of inductive action; the *fifth* is for a permanent magnet; the *sixth* for a sounding box; the *seventh* for a speaking or hearing tube, and the *eighth* for a permanent magnet and plate combined. The claim is not for these several things, but for an electrical telephone in the construction of which those things or any of them are used. Hence the fifth claim is not anticipated as was decided in the Molecular case below. The patent is not for a magnet, but for a telephone of which it forms a part. To that extent the decree in that case was erroneous.

THE DECREE.

It follows that the decree in each of the cases so far as it is in favor of the Bell company and those claiming under it, must be affirmed, and that the decree in the Molecular case so far as it is against that company on the fifth claim of the patent must be reversed, and a decree directed to that extent in its favor. It is accordingly so ordered.

Mr. Justice GRAY was not present at the argument and took no part in the decision of these cases.

JUSTICES BRADLEY, FIELD AND HARLAN DISSENT.

[At the conclusion of the reading of the opinion of the Court, Mr. Justice Bradley made the following remarks.]

Mr. Justice BRADLEY—Mr. Justice Field, Mr. Justice Harlan and myself are not able to concur with the other members of the Court in the result which has been reached. The point on which we dissent is the question of Drawbaugh's invention. We think that Drawbaugh did anticipate the invention of Mr. Bell. We think that the evidence to that point is so overwhelming, both with regard to the number and character of the witnesses, that it cannot be overcome. Of course, it is a question of fact depending upon the weight of the evidence, and involves no question of law, and therefore it is a matter that does not require much observation on the part of those who dissent from the opinion, which is very ably drawn, and undoubtedly presents the whole case with great force. But on this point we cannot concur in the views of the court. We think that Drawbaugh did have an instrument in his shop as early as 1869, which used the variable resistance instrumentality in transmitting articulate speech to a distance, by means of electricity, and was distinctly heard and understood. That is the whole invention, so far as variable resistance is concerned.

We also think that as early as 1871, he did produce an instrument employing the magneto-electric instrumentality altogether, substantially the same as that which is claimed in Mr. Bell's patent. In the one case, with regard to the variable resistance principle, over 70 witnesses were produced. The evidence of some of them may have been shaken with regard to the time that they had in mind; but the evidence of the great majority of them is not shaken at all. They were mostly plain people of the country, but they heard the words, and that is a matter that they could not be mistaken about. It did not require science nor literature nor refinement to understand that.

In regard to the other instrument, some 40 or 50 witnesses were produced who saw it. Many of them heard the language produced through it, and a number of witnesses who did not hear the language produced through these instruments, saw them or heard them talked about, so as to fix the time that they were in existence, and it seems to us that on this subject of time and of result, there is such a cloud of witnesses that it is impossible not to give credence to them. There is no doubt that Mr. Bell's merits are very great in appreciating the importance of the discovery, and in bringing it before the public in such a manner as to make it appear to be what it is, one of the most important discoveries of the century. He was a man whose professional experience and whose scientific attainments enabled him to see at a glance the importance of it. Drawbaugh was a different sort of man. He did not see it. Had he done so, he would have taken measures to interest persons with him in it, and have brought it out. He was a mechanic, a plain mechanic, somewhat better instructed, perhaps, than most ordinary mechanics, a man of more reading, a man of more intelligence. But he looked upon what he made more as a curiosity than a matter of speculation, a matter of financial importance or of importance to the public. That is the way we view his condition of mind in regard to it, and explain why he had not taken more pains to bring it forward to the notice of the public. It is the tendency of the human mind to attach importance to the results and inventions of those who have achieved eminence. Watt was the idol of the British nation, from the time of his first invention of the steam-engine until the day of his death, and until the present time; and everything that was invented about the steam-engine was attributed to him. It was the glory of England, the glory of Watt, and of course every patriotic British subject would hoot at anything it was claimed Watt did not invent, or attribute it to him. That is a principle of the human mind on which we think a great deal may be explained with regard to the feeling towards this important service which Mr. Bell has rendered with regard to this invention. The plain mechanic of Pennsylvania is of no account. The scientific and illustrious—for he is illustrious—Mr. Bell, it cannot be but that he did invent this thing! And yet if Mr. Bell on the 14th day of January (I think it was) or February, when he applied for his patent at the Patent Office, had had in his laboratory the things that Drawbaugh had, he would have been filled with an excitement far exceeding that which has animated the great inventors of the world when they made the discoveries they have made, and he would have exclaimed: "Eureka! Eureka!" He would have appreciated it, if Drawbaugh did not.

What had he when he applied for his patent? On the 10th of June, 1875, they thought they heard something, but were not sure; but he knew the principle and he patented it. Up to the time of making his application for a patent they had not succeeded in producing intelligible speech, more than a word or two; perhaps a word or two. If Bell had done at that time as much as Drawbaugh had done according to the evidence, he would have had no hesitation in claiming the greatest discovery that the world has seen in the present century.

This is an outline of the views which we have on this subject. We have nothing to say depreciatory of Mr. Bell at all, for he has real merits; but we think that this obscure mechanic did do the thing, and that he is entitled to the merit of being the first inventor.

We will take an opportunity within a few days to write a further statement and file it.

THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS, JR.

PUBLISHED MONTHLY BY

THE ELECTRICAL PUBLISHING CO.,

115 Nassau Street, New York city.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
One Copy, Four Months,		1.00
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies, -		.30

[*Entered at the Post Office at New York, N. Y., as second class mail matter.*]

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VOL. VII. NEW YORK, APRIL, 1888. No. 76.

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If any subscribers to THE ELECTRICAL ENGINEER have failed to receive the Supplement issued March 22, *containing the full text of the judgment of the United States Supreme Court in the Appealed Telephone Cases, as delivered March* 19, *they will be promptly supplied on application to the publishers.*

JUDGE MORRISON R. WAITE, Chief Justice of the United States Supreme Court, died at Washington, D. C., March 23.

A VICTORY FOR THE PATENT LAW.

IT is quite difficult to convey an adequate conception of the increase in the value of industrial property based upon patented inventions, which must directly result from the position taken by the Supreme Court of the United States, in the recent decisions in what are known as the Telephone and the Glycerine cases. Looking at the question in its broadest sense, wholly irrespective of particular corporate or individual interests, we do not hesitate to affirm that the public has abundant reason to congratulate itself upon the advanced and unmistakable ground which is now occupied by our highest judicial tribunal in respect to the patent law.

The theory on which the patent legislation of every country is based is that of conferring an exclusive monopoly, of limited duration, upon the original inventor or discoverer of any new art, machine or manufacture, by way of compensation to him for conferring the benefits of such invention or discovery upon the public. The patent is virtually a contract with the government, whereby the inventor is permitted to make what profit he can, and in what manner he may see fit, out of his fellow-citizens during a term fixed by the statute at seventeen years, in order that the community may for ever afterwards enjoy the unrestricted use of the invention, together with all its profits and advantages. Such a bargain is certainly a fair one, and experience has shown it to be a remarkably advantageous one, so far, at least, as the public is concerned; yet in the face of this fact, one after another of the prominent inventors who have rendered the American name illustrious, and who have contributed beyond computation to the industrial progress and wealth of the country, has found himself literally a target for an unceasing torrent of misrepresentation, opprobrium and abuse. We can scarcely recall an exception. Fulton, Whitney, Morse, Goodyear, Howe, McCormick, and, finally, Bell, each has had to endure it in turn with as good grace as possible. But time brings out the truth at last, and the odium of yesterday becomes the applause of to-day.

A number of interesting observations might be made upon the findings of the court in the cases to which we have referred, but we have space to consider only a few of them.

The opinion in the telephone case reaffirms the basic principle, that the person through whom the public derives the benefit of the discovery is the person upon whom the law seeks to confer the reward. It is Bell, not Ries nor Drawbaugh, to whom we are indebted for the benefits, whatever they may be, of the telephone. In the well-known case of the Brush arc lamp, decided adversely to the patent some years ago, the result must have been to sustain the patent, had the inventor's right not been barred by a clearly proven "prior public use" of the device by another, by which phrase it should be understood is meant, not merely a use in public, but a use, although for a short time, for actual business purposes.

We are further clearly instructed in both these cases that an absolute distinction exists between a patent for an art, method or process, and a patent for a machine. While an invention technically termed an art may be nothing more than a new way of using an old machine, it may yet possess patentable novelty in the highest degree, one evidence of which may be the novelty or the great utility of the new result.

Moreover, the important principle has been reaffirmed—and in view of some recent decisions of the federal courts, such reaffirmation would seem to be highly desirable and necessary—that the right of the inventor of a valuable improvement ought not to be abridged by restricting it to the particular embodiment, often a very imperfect one, in which he first gives it the public. The highest order of inventive talent is frequently found dissociated from even an average degree of mechanical dexterity; but to the uninstructed mind the work of the skilful mechanic is often sufficient to wholly eclipse the conception of the thinker, without which the invention in any form could have had no existence.

The opinion in the glycerine cases reaffirms some of the above fundamental doctrines, and teaches the additional lesson that the piracy of patented inventions is not, in a commercial sense, uniformly a profitable pursuit. The infringers, it appears, in this instance appropriated the patented process, but sought to avoid responsibility by employing a different apparatus to work it. They have now had the great truth hammered into them by the Supreme Court, to the tune of $320,000, that a patent for an art is not necessarily restricted to the patentee's specific apparatus, and they have furthermore learned, doubtless with some surprise, that they cannot escape by compulsorily handing over the license fees as paid by honest users, but are to be compelled in addition to disgorge all the profits which they have accumulated by their wrongful and intentional appropriation of the patentee's property.

Finally, the result in both these cases illustrates the importance of properly preparing and prosecuting the application for a patent. If the principal claim of the Bell patent had been but a trifle broader in its scope, it could scarcely have escaped the fate of the celebrated eighth claim of Morse, while, on the other hand, if it had been less broad, it must necessarily have failed to cover some of the many ingenious modifications of which the original invention has been found to be susceptible. Moreover, had the evidence shown the slightest basis for the allegation, so persistently made, that Bell's specification had been improperly amended while in the patent office, it is clear that nothing could have saved the patent.

The finding of the Supreme Court in the telephone case, although doubtless somewhat of a surprise to the general public—which has from beginning to end been persistently and completely misled by the unscrupulous mendacity of the newspaper press—was in effect precisely what had been anticipated in legal circles as well as by laymen familiar with the actual facts. The dissenting opinion, which relates merely to a disputed question of fact, does not in the least diminish the force of the conclusions which we have indicated. The result is a well-deserved triumph for the principles of the patent law with which the inventors of America, and the owners of all property based on inventions have good reason to feel well pleased.

THE PROBLEM OF ELECTRICAL DISTRIBUTION.

At the present time, the columns of the electrical journals are filled, almost to the exclusion of everything else, with literature relating to the distribution of electric energy by alternating currents and induction apparatus. This same subject occupied a prominent place in the proceedings of the National Electric Light Convention at Pittsburgh, where some admirable papers were read, which were printed in our last issue. On the other side of the Atlantic, the Society of Telegraph Engineers and Electricians have recently given up several successive meetings entirely to the discussion of the same topic. The commercial importance of the issues involved, renders it desirable to reproduce some of the more valuable of these papers and discussions, and part of them will be found in another part of our present number.

Not the least interesting of the various contributions to this discussion is the recent publication of the Edison Electric Light Company in advocacy of the direct method of distribution, in which the following assertion is made respecting the alternate current method with converters:

> The large engine-unit requisite, the low economy of the generator as compared with direct current dynamos, the extra loss of energy due to the interpolation of the converter, and the constant demand upon the station made by the converters, irrespective of the work they are doing, all combine to render the system *the most uneconomical yet offered to the public.*

The figures offered in substantiation of the above statement assume the loss in the dynamo to be 10 per cent for the direct as against 30 per cent for the alternating; in the line, 4.7 per cent for the direct as against 5 per cent for the alternating, besides a loss of 4.8 per cent in the alternating converters; total loss of energy 14.7 as against 35.3 per cent, in favor of the direct method.

In reference to this proposition, a contemporary remarks:—"One thing is certain, the advocates of the alternating current system must reply to the challenge, and that speedily, if they wish to hold the position which they have already gained." But we would remind our esteemed contemporary that assertion is not argument; and moreover the question at issue is one which is wholly incapable of being settled either by assertion or argument. If it is indeed true that the indirect method of distribution involves a loss of over 35 per cent of the energy in distributing it, as against 15 per cent by the direct method, something a great deal more potent than counter-assertion will be requisite to enable the "advocates" of the alternating system to "hold the position they have already gained." That exceedingly hard-headed and practical person, Mr. R. E. Crompton, put the matter in a nutshell, when he told the London electricians that the thing wanted was a statement of the efficiency "right out, from the coal-bills to the electricity sold to the consumers."

Every system must start from "taw," that is to say, the price of fuel which all must pay. At the other end of the line the price which the average consumer is willing to give per candle-power for his light is likewise within narrow limits a fixed quantity. Hence the real question, and the only one is, by which method can a given amount of light be produced at the point of consumption at the least cost, remembering that one important element of this cost, is the interest on the original investment, that is, on the cost of the plant.

We now have in this country a large number of central station plants in successful operation both by the direct and the indirect methods of distribution. It is not going to take a very long time, under these circumstances, to determine which of the two methods is, all things considered, the most economical.

Two or three considerations may however be adverted to, that they may not be wholly lost sight of. First.—As a direct current dynamo is in point of fact nothing more than an alternating dynamo, plus a commutator for straightening its current, there is no reason *per se*, why the efficiency of one should be any greater than that of the other. Second.—As it is indisputable that with a given loss of potential in the mains and feeders, the weight and cost of the copper required is inversely as the square of the potential employed, it follows that only one twenty-fifth as much copper will be needed for a potential

of 1000 volts as for a potential of 200 volts, to which must be added on the other hand, the cost of the converters. But the cost per lamp of any converter is a constant quantity and does not increase with the distance from the central station; while on the other hand the cost of copper per lamp in the mains and feeders increases as the square of that distance. These facts render it demonstrably certain that there must be an area surrounding every central station, varying somewhat in extent with the particular circumstances of each case, beyond which the direct method cannot hope to compete successfully with the indirect method. Third.—The difference in the cost of service and interior wiring is not properly an element in the calculation. High potential lamps and small service wires can be used just as well with the indirect as with the direct method, were it not for the fact that the incidental advantages of low potential lamps have been found to more than offset the slightly greater cost of wiring.

The controversy as to the relative merits of the two methods of electrical distribution, like that between paddle wheels and screws in steam navigation, or between broad and narrow gauges in railroading, may be trusted to settle itself. If an innovation possess intrinsic merit, the most violent and long continued objurgations on the part of its opponents are usually received with stony indifference on the part of those who find it profitable to adopt it, while if it is without merit, the public may be trusted to find it out, and that at an early day, in spite of the most ingenious and plausible arguments in its favor.

THE PRACTICAL SIDE OF INCANDESCENT LIGHTING.

Among the many excellent papers presented at the Pittsburgh meeting of the National Electric Light Association, those by Messrs. Wm. Lee Church and T. Carpenter Smith, easily carry off the honors as contributions of the highest importance to the progress of the art of electric lighting; they therefore deserve more than a passing recognition. They are admirable exemplifications of the work which is being done in this country by men in whom a thorough training in theoretical steam and electrical engineering has been supplemented by extensive practical experience and by unprejudiced and intelligent observation.

Each of these papers may be characterized as a plain simple statement of facts, and of deductions therefrom, eminently adapted to appeal directly to the commonsense of the average listener. There is a conspicuous absence of fine-spun theory and of mathematical generalization which, however valuable in their place, could add little if anything to the force of the arguments deduced from the facts so clearly and convincingly set forth.

Incandescent electric lighting has now been before the public for eight years, but it cannot be denied that up to the present time, the financial results have been for the most part, extremely unsatisfactory. A careful study of these two papers goes far to disclose the causes of disappointment. From the nature of the case, the margin of profit in incandescent lighting is rigidly limited, by the price of fuel on one hand and the price of light on the other. Inefficiency, either in the motive power, the electric plant, or the management, in the long run is sure to prove fatal. In view of the mistakes which have been made, in matters large and small, in both the mechanical and electrical details of electric lighting plants, the only reasonable cause for wonder is that the results have been no worse.

Grateful acknowledgement is due to Mr. Smith, in particular, for the candid manner in which he has detailed his own mistakes and failures as well as his successes. Like the true artist, he has grasped the significance of shadow as well as of light, and realizes that a picture containing lights without shadows can give but an imperfect representation of the subject under treatment.

DON'T.

The great activity prevailing in this country at the present time in the principal electrical industries, is very naturally attracting the attention of many young men abroad, especially in England, who after graduating from some technological institution, and providing themselves with unexceptionable letters of introduction to some one in New York, speedily find their way across the Atlantic, in full confidence that remunerative employment awaits them immediately upon arrival.

Our transatlantic contemporaries cannot do many of these young gentlemen a greater service, than to persuade them, if possible, to accept and act upon the celebrated advice of *Punch* to those about to marry. While it is true that most of these persons ultimately find employment in some capacity or other, yet not a few have been compelled to undergo experiences which are, to say the least, exceedingly humiliating to a sensitive soul. Many of them are supplied with barely more than enough money to land them in New York; they then learn, to their dismay, that almost all the electrical establishments of importance are situated at distances varying from 200 to 1,000 miles or more from the metropolis, and can only be reached by an expensive railway journey. They further find, usually to their very great astonishment, that their letters of introduction and of recommendation, so indispensable in Europe, are of little more account on this side of the ocean than so much waste paper. A man in this country always expects to apply for a situation on his own merits. "Influence" goes for little or nothing. If an employer happen to have a vacancy and the applicant appear to be capable of filling it, he is likely to have a chance to try, even though he may be an utter stranger. If he were backed by a personal letter from the President of the United States, it would as a rule make very little difference. One thing is absolutely essential—the candidate must know how to do work with his own hands, and skillfully at that, or he will find there is no room for him in an American establishment.

We do not say this to discourage our English cousins, for we are well aware that many of the most successful electrical engineers in America have come here as young men, from across the seas. But it will save much disappointment if those who may come hereafter start with a definite conception of the industrial conditions and customs of this country, which differ so widely in many respects from those to which they have been accustomed at home.

OUR transatlantic contemporaries are sometimes unintentionally funny. Witness the following, from the editorial columns of a recent issue of the London *Electrical Review*.

That there is a great future for alternating transformers, we have no doubt, for they have indeed a very important present. We can only regret that the system can never give the immunity from accident which a system admitting of storage would be certain to ensure.

Accidents will happen, even to so well regulated a system as that of gas supply. Last Saturday evening a man at the Canterbury gas works turned a handle the wrong way, and instead of increasing the illumination of the city, plunged it into darkness. What a cumbrous proceeding was necessary to rectify this small error! Some hundreds of individuals must have been momentarily at work to undo the work of one. How simple would have been the process if the electric light had been the illuminant—the turning back of the handle would have put all as it was before!

If we were the Archbishop of Canterbury, we would compel every householder, under pain of excommunication, to equip his premises with a storage-tank to hold a sufficient supply of gas for 24 hours' consumption. The illumination of a cathedral city at the mercy of a stupid gas employé, who is clearly unable to distinguish his right hand from his left! Such a system "can never give the immunity, etc."

MR. GOULD having returned from his wanderings in foreign climes, we hope some trusted friend like Mr. Sage or Mr. Field may be deputed to break to him, as gently as may be, the direful intelligence of the impending overthrow of the Western Union monopoly. A new compound of the most energetically explosive character has been discovered, which is to do the business. It is a combination of a Siliconized Copper Wire, and a Machine. It was discovered by Mr. Craig. When we consider what stupendous political convulsions have been precipitated by the agency of Machines, and even by the mere pulling of Wires, we almost feel sorry for Mr. Gould. Mr. Craig's new pamphlet fairly bristles with Startling Facts. We trust General Eckert will keep this brochure out of Mr. Gould's sight as long as he possibly can.

OBSERVATIONS.

Modern Light and Heat, in a recent issue, thinks it remarkable that no one, "so far as it is aware," has ever utilized in practice the suggestion offered by M. Bissot in 1878, to improve upon the ordinary winding of electro-magnets, by returning the wire after completing a layer of convolutions straight to the point of departure, there to begin the next layer, instead of winding it backwards. The statement was made by M. Bissot that by this mode of winding a gain of one-third in power was obtained.

The writer observed this statement in 1878 when it was widely published, and was, as doubtless many others were, considerably impressed with the idea that there was something in it. He tried it, and found that there was nothing in it, and indeed, upon reflection, it is difficult to see where or why any improvement could be expected.

The experiment was also similarly tried by W. H. Preece, who records his results on page 468 of vol. vii. of the Journal of the Society of Telegraph Engineers. These results were identical with those obtained by the writer, and Mr. Preece concludes his statement by saying: "In no case was anything gained by the new method of winding as claimed, but, on the contrary, the old method proved itself to be superior under all circumstances."

It is easy to see that the new mode introduces difficulties into the work of winding, and that the addition of a longitudinal ridge of wire for each layer does not by any means decrease the size or improve the appearance of the helix.

We may naturally infer from the fact that M. Bissot has since his first published statement "lain low," that he was a little premature in his announcement, and that his later experiments in this direction have not fulfilled the promise of their youth.

* * *

THE morning papers of Feb. 13th, 1888, comment upon the death of Hon. Edward Farrar of Keene, N. H., which took place on the previous Saturday, as follows: "He actually invented the first rude telephone in this country, although, owing to his extreme modesty, he never pushed his claim."

This statement would doubtless be generally received with incredulity, were it not that the ascription of extreme modesty, an attribute well known to be a characteristic of original inventors of the telephone, puts it beyond the pale of question. But where are Cushman and his frogs?

The researches of Mr. Farrar have been set forth by Prof. Dolbear in some of his papers on the telephone, and are likewise referred to in a letter published in the *Scientific American* of April 26th, 1879.

* * *

THE necessity of protecting all watches, save and excepting the "Waterbury," from the dire results of magnetization, is now universally recognized; for, though watches once magnetized are curable, the curing process gets to be a bore when it is frequently required.

We are familiar by this time with one or two modes of preventing this magnetization. The first expedient was to encase the watch in an iron shield, this being based upon the well-known ability of iron to short circuit, so to speak, the damaging magnetic rays. It seems probable that to be perfectly efficient the screen applied will have to be thicker than it now usually is.

The other plans which are presented for the favorable consideration of electricians are the construction of the balance, hair-spring and escapement of some non-magnetic metal or alloy. Palladium being evidently a favorite metal for use, either alone or mixed with some other metal or metals. The Paillards, and also the Waltham Watch Co. have adopted the latter mode, the first concern patenting their materials and devices, and the last-named preferring to hold them as a trade secret.

Rumor has it that only two men know the secret now, and that they may die at any moment. It seems as if the abstracts of the old English electrical patents resemble the average patent medicine in that they are ready for every emergency. They are not taken by surprise with the non-magnetic watch. A party by the name of Ulrich, patents on April 22, 1887, "A mode of compensating for the expansion and contraction of the balance spring under variations of temperature, by the employment of such materials for the balance as are not subject to magnetic influence, such as platina, palladium, etc."; and on January 14th, 1856, the same person patents, "Improvements in the compensation balance, destroying its tendency to be affected by terrestrial magnetism or local attraction, on iron ships in particular. In old chronometers a thin armature of iron is used, and in new ones the use of metals not subject to magnetism is recommended, such as brass, silver, aluminum or palladium; all of which goes to prove that Solomon was a good deal of a Solomon after all, when he delivered his celebrated dictum, that "there was nothing new under the sun."

Perhaps he meant that there was nothing so new that no suggestion, idea or thought could be brought up concerning it.

* * *

THE new instrument which numerous public prints have noticed as having been invented by one hight Daniel Drawbaugh for use by armies on land, to detect the approach of troops, or at sea the approach of vessels; and heretofore noticed in these columns, consists by the latest accounts "essentially of a microphone and registering dial: the microphone, an extremely sensitive combination of wire is placed in a HOLLOW iron tube, which is hermetically sealed." If this account be correct, we cheerfully accord the credit of novelty to at least one element of the combination.

ARTICLES.

THE PROBABLE DURABILITY OF HARD-DRAWN COPPER TELEGRAPH WIRE.

BY WM. MAVER, JR.

THE extensive use of hard-drawn copper wire as an overhead conductor was begun in this country in the spring of 1884, by the erection of 2,000 miles of that metal (No. 14 B. W. G.) on the lines of the Baltimore and Ohio Telegraph Company, between New York and Chicago, and by the erection of about 600 miles of similar wire between New York and Boston, by a construction company.

At that time successful results from the use of hard-drawn copper wire were considered by many as very problematical. Indeed, several prominent electricians then expressed the belief that the "experiment" would prove disastrous, and one even staked his professional reputation on his prediction to that effect. A number of reasons were given for these unfavorable opinions. Hard-drawn copper wire would not withstand the extreme cold of our northern winters; the intense heat of summer would elongate it; the strain of supporting its own weight would "fatigue" it—or if it escaped these dangers, it would be carried off for "melting purposes" by the light-fingered gentry of the country through which it would pass. By others, its use was looked upon favorably as a very important undertaking, the results of which, if successful, would be of great value to the telegraph and telephone business; those who were interested financially and professionally in the progress of those electrical pursuits very wisely preparing themselves to note and profit by the consequences.

It would be idle to say that the officers of the Baltimore and Ohio company had no doubts whatever as to the outcome of their undertaking; but whatever their misgivings were, it is sufficient evidence of their confidence in the practicability of it that, after thorough investigation of all the difficulties, they recommended and authorized the erection of the 2,000 miles of wire referred to.

The results, however, as is now well known, fully justified their confidence in the undertaking. The summer of 1884 passed without any undue "drawing out," and the cold snaps of the winter of 1884–'85 came and went without damage to the copper wire. Indeed, the reports from the linemen were more encouraging than otherwise, inasmuch as they showed that the percentage of breaks after cold "snaps" was no greater than that of parallel iron wires, More than that, these reports showed that the majority of the breaks of the copper were preventable, having occured at places where the wire had been inadvertently nicked or at improperly made joints. As for losses due to thefts of the copper wire, they were nil, and the table of results of tests given below will show that "fatigue" has not as yet made itself felt.

The knowledge of these facts was easily accessible to any one desiring it; and that they were considered fairly satisfactory may be gathered from the fact, that whilst in January of 1884 there were probably not more than 100 or 200 miles of hard-drawn copper in use in this country, to-day there are, it is estimated, at least 50,000 miles representing about 4,200 tons of metal, now operated by the various telegraph and telephone companies, the average weight per mile being about 170 lbs.

While the officials of the Baltimore and Ohio Telegraph Company felt sufficient confidence in the capacity of hard-drawn copper wire to serve the purpose of an overhead conductor, they realized from the start that it was essential to the success of the undertaking that the utmost care should be exercised both in the manufacture of the wire and in its erection upon the poles. So far as the manufacturers were concerned, it is but fair to say that they fully appreciated this necessity and exerted themselves accordingly, accepting without complaint the rejection of miles of wire for minor defects which to-day, with the knowledge of what margin is allowable, would not raise a question.

On the other hand the telegraph company required the strictest compliance with the rules promulgated for the handling and erection of that class of wire—new methods of making sleeve joints; new or revised ways of tying the wire to the insulator, etc., were adopted, and special pliers were devised and furnished for the making of joints, etc. Particular instructions were given to guard against nicking the copper in any way, the linemen being forbidden to use anything but the hands in handling the wire, the pliers above referred to being employed to hold the sleeve firmly during joint making. The nicking of the wire was soon found to be its weak point, a fact which will be made apparent to any one by drawing the edge of a knife lightly around the circumference of a hard-drawn copper wire, so as to make a mark; on bending the wire it will invariably break clear off at the mark.

Strict attention to every detail in the erection of this wire has ensured successful results, while the unsuccessful results are mostly traceable to neglect of such details, and the handling of the copper wire as linemen are accustomed to handle iron wire.

The predictions of immediate disaster to the users of hard-drawn copper wire having been satisfactorily disposed of, the question as to its probable useful "life" as an overhead telegraph and telephone conductor becomes an important one, and such data as it has been possible to gather at all systematically, in the four years since its introduction on a large scale, will perhaps prove interesting.

During the three and one-half years in which the Baltimore and Ohio Telegraph Company used its 8,000 miles of hard-drawn copper—about equally divided between No. 12 and No. 14 B. W. G.—half yearly tests and inspections were made of it.

With a view of obtaining practical data from which to ascertain the "standing up" qualities of the wire under as many different conditions of temperature and weather as possible, and as to its durability under circumstances that were known to be quickly destructive of iron wire, the specimens from which the tests were made were taken from the lines of that company in the states of New York, Pennsylvania, Ohio, Illinois, Indiana and Arkansas; from the cities and counties, and the vicinity of smelting and coke furnaces.

—	No. 12 B. W. G. 170 lbs. per mile.						No. 14 B. W. G. 110 lbs. per mile.					
	Specimen No.	Diameter inches.	Tensile strength.	Elongation per cent.	Ductility. Bends on itself.	Ductility. Twists in 6 inches.	Specimen No.	Diameter inches.	Tensile strength.	Elongation per cent.	Ductility. Bends on itself.	Ductility. Twists in 6 inches.
Tests before shipment of wire from factory, 1884.	1	.104	564	.8	3	33	1	.063	335	1.	3	25
	2	.104	572	1.	3	54	2	.083	355	.85	2½	28
	3	.104	580	1.	3	34	3	.083	362	1.25	3	30
	4	.104	560	.5	3	45	4	.083	340	1.	3½	38
	5	.104	576	.5	3	50	5	.083	345	1.	3	30
	Average	.104	570.4	.76	3	43.2	—	.083	347.4	1.02	3	30.2
Tests after nearly four years' service, 1887.	1	.104	592	.8	3½	27	1	.083	370	.8	3	35
	2	.104	595	1.2	3	35	2	.083	365	.8	3½	40
	3	.104	513	2.2	3½	40	3	.083	350	1.	3	25
	4	.104	580	.8	2½	38	4	.083	350	1.25	3	35
	5	.104	580	1.4	3½	24	5	.083	345	.8	3	33
	Average	.104	572	1.28	3½	32.8	—	.083	356	.93	3.1	33.6

The chief linemen throughout the service were also instructed to observe closely and report to headquarters any instances of abnormal deterioration of the copper wire as compared with iron wire, and the electricians of the company made periodical personal inspections of the wire for the same general purpose.

The table gives results of mechanical tests of No. 12 and 14 B. W. G. copper wire made before the wire left the factory, and also after nearly four years service. The tests for the year 1884, are samples of many made on behalf of the company by a competent expert. The table for the year 1887, shows actual tests of specimens taken at random from different points of the company's system. All of these mechanical tests were made by the same expert using the same machinery, so they may be considered fairly comparative.

The average of a series of tests for tensile strength of sleeve joints carefully made at headquarters was 545 pounds for No. 12, and 331 pounds for No. 14 B. W. G. copper. The average of a series of similar joints made by the linemen in regular work and taken from the lines after they had been in service from two to three and one-half years was 530 pounds for No. 12, and 320 pounds for No. 14 B. W. G. As already said the foregoing tests do not appear to show any signs of tendency to "fatigue" or weakening of the metal. The tests made after the wire had seen service showing no appreciable loss of strength.

Careful examination of all the specimens, including the latest received from different sections of the country, fail to disclose any signs of deterioriation. Specimens taken from the open country, away from the railroad, are simply tarnished by exposure. Those from cities and the neighborhood of furnaces are coated more or less thickly with a sooty substance easily removable, and measurements of the wire after the removal of the coating by washing show no diminution of the diameter.

Accompanying one specimen of No. 14 wire, erected in June, 1884, and in first-class condition when received in the latter part of 1887, was a note by the superintendent to the effect, that a No. 14 steel telephone wire on the same poles and vicinity, namely, the drill yard of the Chicago and St. Louis Railroad, Cleveland, O., had been completely corroded in one year. The only unfavorable comments received from the chief linemen with regard to the use of copper wire were relative to the No. 14 wire, which some of them considered of too low tensile strength, more especially in wooded country, as in many cases it would give way under the strain of a broken bough falling, which a slightly stronger wire would have upheld until the bough could have been removed. This opinion of No. 14 wire, as regards tensile strength, is now generally entertained by telegraph and telephone people; and it is not likely that wire much lighter than 170 lbs. per mile will be extensively used hereafter.

Careful enquiry among the majority of the most extensive users of hard-drawn copper wire has elicited the information that the foregoing general results have been verified by their experience.

While, therefore, the successful experience of the past four years may not be considered sufficient to justify a definite prediction of the "life" of hard-drawn copper wire, it will doubtless be admitted generally that it is sufficient, in view of the already well known superior durability of copper over iron under ordinary atmospheric conditions, to warrant the prediction that it will incomparably exceed that of iron wire.

But these remarks, it should be understood, refer only to such hard-drawn copper wires as have had the advantage of careful attention during manufacture and erection, without which—experience has already shown—wires would soon stand in need of reconstruction.

It may not be amiss to comment on the probable effect of the recent decided advance in the price of copper, on its further use for telegraph and telephone purposes.

It has been stated in some quarters, in connection with this advanced price, that the superiority of hard-drawn copper over iron for telegraph and telephone purposes is not sufficiently well established to warrant the companies in continuing to purchase it in preference to iron at the existing high figure. The question is an interesting one. There is little doubt that the low price of copper in 1884 played a large part in the extensive adoption of hard-drawn copper wire as an overhead conductor. It is not probable that, in the face of the uncertainty which existed at that time as to its "standing up" qualities, any company would have been inclined to invest capital in that metal if iron wire, whose qualities in that respect were well known, was to be had at a much lower figure. But now that the practical utility, that is the "standing up" quality of hard-drawn copper wire has been satisfactorily demonstrated, it is unlikely that the present artificially advanced price of copper will do more than temporarily retard or limit its use, if it does that.

There are several reasons for this view. In the first place the electrical properties of copper wire are so greatly superior to iron, especially for long-distance telephony, that its continued use for this purpose is almost if not altogether imperative. Its use in telegraphy has certainly been advantageous. Even at the increased price of copper its cost as compared with iron, electrically considered, is about equal if indeed the advantage is not with copper. For instance, a copper wire having a resistance of, say, 4.44 ohms per mile will weigh about 200 pounds, which at 22 cents per pound, cost $44. An iron wire of the same resistance will weigh about 1,100 pounds, and at 4½ cents per pound, cost $49.50. In addition there is the important advantage possessed by copper wire that, when from whatever cause or causes its day of usefulness as an electrical conductor has passed, it still will have a certain intrinsic value as old copper. Whilst old iron telegraph or telephone wire at that stage of its existence known as the "streak of rust" condition, is not worth to any one the expense of removing it from the poles.

Which considerations apparently lead to the conclusion, that unless the copper "trust" forces the price of copper to a point higher than it has as yet seen fit to raise it, that metal will still be more or less extensively employed in the telegraph and telephone service.

CONSTANT CURRENT AND CONSTANT POTENTIAL MOTORS IN PRACTICE.

BY J. A. POWERS.

The field for electric motors in connection with electric lighting plants is being rapidly developed, and the problem as to the proper systems to be used in each locality is becoming a very pressing one. This question must be, to a certain extent, influenced by the individual condition of existing plant and the probable extent and distribution of territory in reference to the location of the central station already constructed.

The time for separate power stations has not yet come, and it seems doubtful if it will, save in exceptional cases, since the cost of skilled labor counts so heavily in the maintenance of both electric light and power stations as to make it advisable to keep the two kindred industries under one management and roof.

This being granted, the question of economic distribution will be a most important one, as the best fields for lighting and power are seldom found together; it is true that the electric motor has released the small manufacturers from the bonds which tied them to the districts where power was to be had; but the power question will not be long confined to the small manufacturer and the large manufacturer. The user of from 10 h. p. up is frequently the owner of his mill or factory or the holder of a long lease. These conditions must determine the choice of a power system, and the corollary to be drawn from this is the question of expense of lines.

Power deals with larger units than light, and means much larger investments for line copper whatever system be employed. Motors of 25 or 50 h. p. will not be uncommon in cities of 50,000 population; but the customer using

the same electrical energy in lighting will always be much more rare, and the average lighting hours will be much shorter than the hours for power. The question of cost of lines becomes, therefore, a very important one.

Constant potential of 110 or 220 volts means a territory restricted to about 2,000 feet from the station, and at this distance a line loss of not less than 10% for any investment within reason for line copper.

These voltages will always be crippled in this range of distribution, and except for large cities will probably not have a wide use for power systems. Each horse-power conveyed 2,000 feet on a line loss of 10% will, with 220 volts potential, involve an investment of about $16 or $18 for copper at 20c. per pound.

The one great advantage of the system is absolute safety in handling. Two hundred and twenty volts gives a shock only disagreeable in its effects. The question of putting out motors on incandescent lighting circuits of this kind has been settled by experience to be not practical to any extent without serious disturbance of the lights. This necessitates the adoption of separate lines where motors of any considerable size are in use.

Constant potential systems of from 400 to 600 volts are the outcome of the heavy expense of lines for the low potential systems. They relieve to some extent the question of line cost, but do so at some expense of personal safety, as every motor carries the full 400 or 600 volts at the brushes, and accidentally touching both poles will cause a heavy shock. The question of danger by grounding while handling the motors also appears as an element of danger. It is doubtful if a voltage of 600 will cause death even with heavy currents, unless the person be predisposed to heart difficulty or some kindred organic trouble; but the point of safety has probably been passed with the 400 unit mark. Considering this to be so, and that 600 volts is the extreme limit of safety for constant potential, with a 10% line loss we can reach a distance of 4,000 feet of $9 to $10 per horse-power for line copper at 20c. per pound. This approaches the reasonable; but a lighter expense would expedite matters in the leasing of large power where the margin of profit is smaller and the item of interest consequently of more importance.

The use of a series system of electric motors has been greatly hindered by the difficulty of obtaining good speed regulation. In the case of constant potential this point solves itself by making the motor with a simple shunt-wound field. The point is so easily achieved as to be generally regarded as a sufficient solution of the whole motor question. That this solution is not a true one many facts in the operation of series motors go to prove.

The question of regulation once economically solved, the question of cost of copper falls to its minimum at once, with the increased voltage.

The fact that more people are killed by constant current or arc circuits than by constant potential, seems by most motor manufacturers and many station operators to be satisfactory proof that they are the most dangerous for all purposes, regardless of the disproportion in the number of such lines and machines in use as compared with high voltage constant potential circuits, and also unmindful of the fact that by far the larger proportion of such accidents are due to bad insulation. That arc machines of high potential are dangerous is not considered to be sufficient cause to prohibit their use in central stations, and, as a matter of fact, machines of 50 to 60 light capacity have the preference in spite of the increase of danger with the increase of potential.

Constant current motor circuits of 10 amperes are the most convenient for existing arc stations. They have the disadvantage of liability to failure from open circuits, which the ordinary wire (No. 6 Brown and Sharpe gauge) is not heavy enough to form an entire safeguard against.

The limit of safety from shock (taken at 400 or 600 volts) is soon reached at about five to six h. p., and the question of insulation forms an important part of the cost of the line if it receives the attention necessary to avoid all possible chances of ground.

The proper remedy for the cure of these defects is to increase the current to say 40 or 60 amperes, when the limit of safety from shock at the brushes is at once advanced to 20 or 30 h. p., while the cost of insulation per h. p. on the line is considerably less. As to the total E. M. F., there is no more reason to restrict the E. M. F. of motor lines than of arc lines on which the limit is about 2,000 to 2,500 volts. The first cost of the copper on such lines is not over one-fifth that of constant current lines of 400 to 600 volts for equal distances, which will allow the best of insulation being employed and still leave a wide margin of savings.

The danger of open circuits from rupture of lines would be much reduced, and the wire, No. 2 to 4 B. & S., would be as heavy as can be conveniently handled when heavily insulated.

The one necessary point for safety is to place the motor out of reach of ground connection. A cut-out of much heavier and larger construction than for arc lighting would be required to disconnect the line when not in use.

A year's experience in the operation of arc motors has confirmed opinions previously formed of the freedom from burning out of armatures. With an average of about 25 motors in use, two cases of burned armatures have occurred, both from grounding on the iron core, neither being from overheating. One of these cases occurred within a few hours of starting the motor, and was due to bad insulation.

Much has been said of the lack of efficiency of series motors under light loads. Recent tests on motors of one-half and one h. p. show, with 10 amperes of current in the line, 21 per cent. of the E. M. F. under full load when the motor was running light without the belt. The average E. M. F. in use was about 50 per cent. to 60 per cent. of the full E. M. F. required to develop the rated power of the motor. This is very satisfactory in a financial point of view. The readings were limited to one-half and one h. p. motors by the range of the voltmeter used, which was a Thompson-Rice, rated only to 150 volts.

The proof of the pudding is, after all, in the eating, and that after running a single motor for nearly six months to test its durability, there were obtained in the following six months orders for 90 h. p. of series motors, best illustrates the fact of their satisfactory performance.

One point of great economic value shows up sharply in using series instead of shunt motors. The customer cannot use more than the rated power of the motor unless the speed is increased. This is, of course, easily detected. When the motor is overloaded it simply slows down, and as this is precisely what the small steam engine does under like circumstances, it presents no objection to the average user of power, who would otherwise load his motor as long as it would carry load, and in the case of a shunt motor would insist that his motor was not overloaded "because it did not slow down any."

A recent case came to the notice of the writer of a 10 h. p. constant potential motor which rented for $700 per year, and which the ammeter showed was doing 18 h. p. of work.

It is believed that when the advantages of series motors become more fully known they will have the preference in such miscellaneous work as is called for in central stations practice. They are certainly not so liable to cause such dangerous shocks as high voltage constant potential systems by contact across the poles, as the maximum potential on the largest motor should never exceed that in use on high constant potential systems, while with the smaller motors, which are presumably handled by a more careless and ignorant class of people, the potential across the brushes hardly exceeds that of the multiple arc motor of low potentials. The one danger, as before stated, is from

carelessness in locating the motor within reach of ground connections. The cure for this is like the well-known remedy for the cure of hens which eat their eggs, viz., cutting their tails off close behind their ears, and buying new hens. See that the motors are carefully installed, use the best insulation money can buy, put it up with care, and there will result a motor plant, safer to handle, cheaper to install, cheaper to run, and cheaper to maintain, than any multiple arc system of either high or low potential.

FORMULÆ FOR TRANSFORMERS.[1]

BY PROFESSOR GEORGE FORBES, F.R.S. (L. AND E.).

THE modern transformer for electric lighting is an induction apparatus in which the primary coil is of high, and the secondary of low, resistance, consisting of two ring coils of insulated copper wire enclosed in an iron sheathing, so subdivided as to prevent the formation of local currents in the iron when subjected to the influence of alternating electric currents in the coils. The terminals of the primary are kept at a constant mean difference of potential. The secondary circuit includes the lamp circuit, and is of varying resistance. The iron is so situated with respect to the coils that there is no free magnetism; this simplifies the mathematical treatment of the phenomena.

It is required to predict (1) the magnetic induction in the iron, (2) the work given off to the lamp circuit, (3) the whole work absorbed by the apparatus, (4) the waste of energy when no lamps are in circuit, and (5) the effect which will ensue from varying the construction of the apparatus. The first of these has been approximately solved on the assumption that the permeability of the iron is constant.[2]

It is generally assumed that in such a system of electrical distribution the electromotive forces, the electric currents, and the magnetic induction are simple harmonic functions of the time. This would not be the case if the phenomenon called by Ewing "magnetic hysteresis" is taken into account, and in a preliminary investigation this must be omitted. Its effect in practice is insignificant so long as the magnetic induction in the iron is not high.

The notation now adopted is as follows:—

p_1 = number of turns in the primary coil.
p_2 = " " " secondary coil.
r_1 = resistance of the primary coil.
r_2 = " " secondary circuit, including lamps.
c_1 = current in the primary circuit.
c_2 = " " secondary circuit.
m = integral of the induction over the cross-sectional area of the iron.
$\rho = \dfrac{\text{mean length of lines of induction in the iron.}}{\text{cross-sectional area of iron} \times \text{permeability.}}$
$n = \pi \times$ number of alternations of E. M. F. per second;
$= 2\pi \times$ " " complete periods of E. M. F. per second.
w_1 = work done in unit time by the primary current.
w_2 = " " " in the secondary circuit.
e = difference of potential of primary terminals.

C. G. S. units are adopted throughout.

Assume
$$m = \mathrm{M} \sin n t \quad . \quad . \quad . \quad . \quad . \quad (1)$$

then
$$c_2 = -\frac{p_2 d m}{r_2 d t} = -\mathrm{M}\, n \frac{p_2}{r_2} \cos n t \quad . \quad . \quad (2)$$

and
$$w^2 = \int_0^1 c_2^2 r_2 dt = \frac{\mathrm{M}^2 n^2 p_2^2}{r_2} \int_0^1 \cos^2 nt = \frac{\mathrm{M}^2 n^2 p_2^2}{2 r_2} \int_0^1 (1 - \cos 2nt) dt.$$

The mean value of the periodical part is zero. Hence
$$w_2 = \frac{\mathrm{M}^2 n^2 p_2^2}{2 r_2} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Again,
$$\mathrm{M} \sin n t = \frac{4\pi}{\rho} (p_1 c_1 + p_2 c_2);$$

whence
$$c_1 = \frac{\mathrm{M}\rho}{4\pi p_1} \sin n t + \frac{p_2^2 n \mathrm{M}}{p_1 r_2} \cos n t \quad . \quad . \quad (4)$$
$$= \mathrm{C}_1 \sin (n t + a),$$

if
$$\mathrm{C}_1 \cos a = \frac{\mathrm{M}\rho}{4\pi p_1} \text{ and } \mathrm{C}_1 \sin a = \frac{\mathrm{M} p_2^2 n}{p_1 r_2}.$$

Again,
$$c_1 = \frac{\mathrm{E}}{r_1} \sin (n t + \beta) - \frac{p_1}{r_1} \frac{dm}{dt}; \text{ if } e = \mathrm{E} \sin (n t + \beta),$$
$$= \frac{\mathrm{E}}{r_1} \cos \beta \sin n t + \left(\frac{\mathrm{E}}{r_1} \sin \beta - \frac{p_1 \mathrm{M} n}{r_1}\right) \cos n t \quad . \quad (5)$$

Equating coefficients in (4) and (5), we have
$$\mathrm{E} \cos \beta = \frac{\mathrm{M}\rho r_1}{4\pi p_1}; \; \mathrm{E} \sin \beta = \mathrm{M} n \left(p_1 + \frac{p_2^2 r_1}{p_1 r_2}\right)$$
$$= \mathrm{M} n p_1 \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right);$$

whence
$$\frac{\mathrm{E}^2}{\mathrm{M}^2} = \left(\frac{\rho r_1}{4\pi p_1}\right)^2 + n^2 p_1^2 \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right)^2 \quad . \quad (6)$$

also,
$$w_1 = \int_0^1 c_1 e\, d t = \mathrm{C}_1 \mathrm{E} \int_0^1 \sin (nt + a) . \sin (nt + \beta) . dt$$
$$= \frac{\mathrm{C}_1 \mathrm{E}}{2} \int_0^1 \{\cos (a = \beta) - \cos (2 n t + \beta + a)\} d t$$
$$= \frac{\mathrm{C}_1 \mathrm{E}}{2} \cos (a - \beta) = \frac{\mathrm{C}_1 \mathrm{E}}{2} (\cos a \cos \beta + \sin a \sin \beta)$$
$$= \frac{\mathrm{M}^2}{2} \left\{ r_1 \left(\frac{\rho}{4\pi p_1}\right)^2 + \frac{n^2 p_2^2}{r_2} \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right) \right\} \quad . \quad . \quad (7)$$
$$= \frac{\mathrm{E}^2}{2} \cdot \frac{r_1 \left(\frac{\rho}{4\pi p_1}\right)^2 + \frac{n^2 p_2^2}{r_2} \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right)}{\left(\frac{\rho r_1}{4\pi p_1}\right)^2 + n^2 p_1^2 \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right)} \quad . \quad . \quad (8)$$

When the actual figures pertaining to a modern transformer are inserted, it is found that the quantity $\frac{p_2^2 r^1}{p_1^2 r_2}$ is less than .01; that the first term of the numerator in (8) is small compared with the second; and that the first term of the denominator is very small compared with the second.

The efficiency is found by dividing (3) by (7).

When no lamps are used on the secondary circuit, the rate of work done is, by (7) (r_2 being infinite),
$$\text{waste} = \frac{\mathrm{M}^2}{2} r_1 \left(\frac{\rho}{4\pi p_1}\right)^2.$$

It will be noticed that the efficiency of the apparatus depends on the first term in (7) being small compared with the second; hence n (or the number of alternations per second) may be diminished without loss of efficiency if ρ be diminished, or if the mass of iron be increased.

1. Paper read before the Society of Telegraph Engineers and Electricians London (Eng.), February 9, 1888.
2. J. Hopkinson, *Proc.* Roy. Soc., 1887.

WHY PROFITS DWINDLE.

BY D. C. JACKSON.

IN the struggle between cheapness and economy in electric light plants, it is surprising that economy is so frequently permitted to go to the wall.

Many of the plants erected in the eastern portion of the country during the last three years show that the investors have partially learned the advantages of plants in which there is to be found only thoroughly first-class workmanship. In a few plants careful attention has been given to the designing and construction of every part of the system, from the setting of the boiler, where the heat energy is first gathered from the coal, to the filament of the lamp, where this energy undergoes its final useful transformation. The performance of such plants has thoroughly proved the economy of first-class construction.

In the west, where coal and supplies are particularly costly, while money commands a large return in legitimate business channels, it would seem rational to expect the question of economy to receive the earliest consideration. In order to make electric lighting pay to western capital a fair return, the highest perfection of mechanical and electrical details must be observed; still, under these conditions, cheapness holds almost undisputed sway. This is in part, no doubt, due to the general hurry for improvements in the west; but there are more potent causes, not to the credit of the parent companies who have erected the plants.

The writer can name a number of plants in towns of 2,500 to 50,000 inhabitants, located between the Mississippi River and the Rocky Mountains, some of which are paying no dividends on their stock, others that are giving a fair return. All of these would readily have paid, with their present receipts, a percentage dividend ¼ or ½ greater on the slightly increased capital required, if the plants had been put in on an economical basis, making them gilt-edged in the eyes of the engineer and truly gilt-edged for the investor.

Some of the faults to be observed in plants now working, are due to the installation of a system entirely unsuited for the work required; some are in electrical details and line construction, causing the cost for repairs to consume all profits. Others are to be found in the steam plants, the voracious coal eating of which causes the receipts to slip between the fingers of the stockholders into the pockets of the coal dealers. Where the cheapest slack coal costs $3.75 per ton, a cheap boiler, poorly set, and an engine consuming 20 lbs. of coal per horse-power per hour, should find no place in an electric light plant; but the writer is well acquainted with a small incandescent plant running under exactly such conditions in a town of 3,000 people. It is truly surprising that this plant earns a fairly good dividend.

There are arc plants, the line wire of which is composed of all sizes from No. 7 to No. 4 spliced together, and in which the poles will soon be flat on the ground, on account of their shallow setting; others where half the lights go out on every damp night, because of poor insulation.

In multiple series systems are found incandescent lamps that have been made for use on constant potential circuits, where, let us hope, they would be uniform; but when placed in a group, all of which must receive the same current, lamps of normally 16 c. p. vary amongst themselves from 12 to 25 candles.

In one plant that has fallen under the writer's observation, the poles average about 40 feet in height, and originally were nearly all composed of short poles spliced together in the most slovenly manner. It is needless to say that under the stress of a number of large wires some of these poles threatened to collapse, making it necessary to replace them out of the receipts of the local company. Another case of bad line construction needs no comment here. Three guy stubs are placed in a row to hold one corner pole. The pole was 40 feet high and the first stub set was thirty feet long with a very small top and a splice in the middle. The splice broke, and another stub was set 50 feet back of the first to hold it up. This in turn was set too shallow, and was in a fair way to be pulled out of the ground, when a short stub was placed back of it to hold it down. It may be well that the western people care more for utility than beauty; but such a disfiguration of the streets with poles is carrying the matter a little too far.

These examples are but a few of many that can be put in evidence to show the grossly bad construction put in by the "experts" of some of the largest parent companies.

When under competition in a place where there is no fear of the insurance inspector, the companies apparently vie with each other as to which can erect the cheapest and most unsubstantial plant. The item of profit to the local companies is too insignificant for consideration.

Under such treatment, economy is necessarily lost; and electric lighting naturally loses favor with the investors. There is abundant proof that, where properly installed and well managed, an electric light plant will always produce large dividends on invested capital. That so many plants are losing money is due chiefly to the culpable management of the parent companies, through their agencies, aided by the impression of the public that all things electrical must be *good* without gradation of quality.

LINCOLN, Neb., March 13, 1888.

ON ALTERNATE CURRENT TRANSFORMERS, WITH SPECIAL REFERENCE TO THE BEST PROPORTION BETWEEN IRON AND COPPER.[1]

BY GISBERT KAPP.

THE principle on which all induction coils, and therefore all the different forms of alternate current transformers, depend is that of a magnetic circuit interlacing with an electric circuit. In its simplest form this relation can be represented by two rings threaded through each other, figure 1, one representing the electric circuit and the other the magnetic circuit. Modern transformers have all a closed core, so as to compel, as far as possible, all the lines of the magnetic circuit to pass through the electric circuit, which consists of a primary and secondary coil; but they differ from each other in the particular manner in which the circuits are arranged, with a view to attain the following objects: reduction of the length of the two circuits, reduction of the weight of materials employed, ventilation, facility of manufacture and repair, efficiency of insulation, and reduction of cost of manufacture. Omitting for the present those considerations which more nearly concern the practical manufacture, we may divide transformers broadly into two classes—one in which the copper coils are spread over the surface of the iron core, enveloping the latter more or less completely; and the other in which the core is spread over the surface of the copper coils, forming a shell over the winding. I propose to call the former "core transformers," and the latter "shell transformers." A familiar example of the first class is the armature of an ordinary Gramme dynamo, while the particular type of transformer introduced by Mr. Zipernowski may serve to illustrate the second class. They are represented in the diagrams figures 2 and 3. It is evident without mathematical investigation that, whatever may be the proportion between the external and internal diameter of the ring, the electric circuit must be shorter than the magnetic circuit in the Gramme ring or core transformer, while the opposite must be the case in the Zipernowski ring or shell transformer. When, a few years ago, this type was introduced, it was, on account of its short magnetic circuit, generally believed to be an immense improvement upon the Gramme ring; and I have heard it stated that with the Zipernowski outside core absolute perfection has been reached, since "every inch of copper wire contributes to produce electromotive force." I propose presently to lay before you a short investigation into the relative merits of the Gramme and Zipernowski rings, and also into the best proportion of copper to iron in either; but before entering into this subject I would submit a few theoretical considerations, so as to obtain a basis for this investigation.

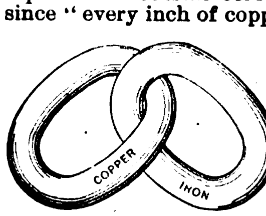


FIG. 1.

Since the electromotive force developed in the secondary circuit is proportional to the co-efficient of mutual induction between that and the primary circuit, and since self-induction tends to produce lag and so reduce the output of the apparatus, it is obviously advantageous, both for efficiency and output, to so arrange the coils that their co-efficient of mutual induction should be a maximum for the given co-efficients of self-induction in the primary and secondary circuit. According to a well-known law, the maximum value which the co-efficient of mutual induction can have is equal to the square root of the product of the two co-efficients of self-induction; and the necessary and sufficient condition for obtaining this maximum is that the same number of magnetic lines of force should pass through both circuits. In other words, the whole of the flow of force should take place within the core, and no free poles should be formed. This condition can easily be fulfilled by a suitable arrangement of the two circuits in close proximity, and, as a matter of fact, is fulfilled in all modern transformers. We shall, therefore, assume that the same flow (F) of magnetic lines of force passes through both circuits, and that the electromotive forces produced in the two circuits bear to each other the same proportion as their respective

1. Read before the Society of Telegraph Engineers and Electricians, February 9, 1888.

number of turns. We shall further assume that the electromotive force impressed on the terminals of the primary coil, or the current sent through it, is a simple sine function of the time—in other words, that the electromotive force developed in the armature of the dynamo is such a function. Whether the latter condition is generally fulfilled by modern machines I am unable to say; but I believe that the presence of a transformer in the circuit has the tendency to smooth down any deviations from a true sine curve should they occur in the armature, and, further, that a curve of E. M. F., of whatever shape, produced by a machine will, after filtering through two or three transformers, come out as a true sine curve. It would be of value if some one having the necessary mathematical attainments would investigate this point; but for our present purpose it is sufficient to assume that the electromotive force produced by the machine follows with fair approximation a simple sine function, and that the deviations are unimportant. This assumption has up to the present been made by all who have investigated the subject of transformers.

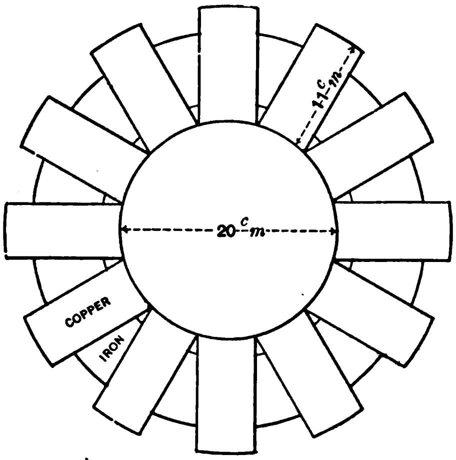


FIG. 2.

Let, in the following:

n represent the number of complete cycles performed per second;
F " " flow of force in C. G. S. lines;
B " " maximum inductions (crest of wave);
τ " " number of turns in the coils, the indices 1 and 2 being used to distinguish the primary from the secondary coil;
E " " maximum electromotive forces (crest of wave) in volts, the indices 1 and 2 being used to distinguish the primary from the secondary coil;

$e = \frac{\sqrt{E}}{2}$ represent the average electromotive forces;

I represent the maximum currents;

$i = \frac{\sqrt{I}}{2}$ represent the average currents;

L represent the length of the magnetic circuit in centimeters;
a " " area of core available for the flow of lines in square centimeters.

$R = \frac{L}{a}$ represent the magnetic resistance of the core;

μ represent its permeability;
r " the electric resistances;

then we have the following well-known relations:

$$B = \frac{F}{a}; = \frac{\mu\, 4\, \pi\, \tau\, I\, 10^{-1}}{R}; E = 2\, \pi\, n\, F\, \tau\, 10^{8}; \frac{E_1}{E_2} = \frac{\tau_1}{\tau_2}.$$

Calling e'_1 and e'_2 the average electromotive forces at the primary and secondary terminals respectively,

$$e'_1 = e_1 + r_1\, i_1;\ e'_2 = e_2 - r_2\, i_2.$$

When a transformer is at work we have the following phenomena:

1. A wave of impressed primary electromotive force.
2. A wave of counter electromotive force in the primary coil, but not exactly coinciding with the impressed.
3. A wave of primary current not coinciding with either.
4. A wave of magnetization lagging behind the primary current wave by something less than a quarter period.
5. A wave of electromotive force in the secondary coil lagging behind the magnetization wave by a quarter period.
6. A wave of secondary current, coinciding with the former (5) in period if the external circuit contain no self-induction—a condition approximately fulfilled where the current is only used for lighting glow lamps.

The problem now is to find what relations exist between these different waves as regards their relative positions and magnitudes. At first sight it may seem that this would prove a very difficult problem; and if an algebraic solution be attempted it is, in fact, if not very difficult, at least enormously complicated; but it is easy to treat the matter geometrically in a very simple way. As this method has already been published some time ago, it will not be necessary to demonstrate it, and I shall limit myself to a brief description, pointing out a modification of the original method by which the energy dissipated in magnetizing the core can be taken into account. It will be seen from the above equations that F and E are proportional. Consequently, if we know what E. M. F. is to be put on the primary terminals of a given transformer, we also know with very close approximation what the induction and total flow of lines will be. If it were not for the slight disturbing influence of the resistance of the primary coil, we would know these data exactly. But the loss of E. M. F. by resistance can, for obvious reasons, only be trifling, and will in most cases be settled beforehand. We can therefore determine F with perfect accuracy, and from the constructive data of the core also the exciting power ($\tau\, I$) which will produce this flow. It will be shown presently that it is inexpedient and uneconomical to work transformers with a high induction, and we may therefore regard the permeability to be constant for all points in the cycle. In this case $\tau\, I$ and F, must at all times be proportional. Let, in figure 4, the circle represent the effective exciting power which we assume to coincide with the magnetization, so that the projection on the vertical of the radius $O\, P$, as it revolves (clockwise) round O, represents the effective exciting power in ampere turns, and, to a different scale, also the flow of force at any instant. The line representing the current in the secondary must evidently lag behind $O\, P$, by a quarter cycle, and can be calculated from the formula for E_2, and from the resistance of this circuit. This gives us $O\, I_2$, the maximum exciting power due to the secondary coil alone. By erecting a vertical on $O\, P$ in P, and making $P\, I_1 = O\, I_2$, we find the line $O\, I_1$, which represents in position and magnitude the maximum exciting power due to the primary coil alone. This gives us also the primary current, and we can now determine the loss of electromotive force due to the resistance of the primary coil. Let $O\, R_1$ represent this in direction and magnitude. The counter electromotive force in the primary must evidently be in advance by a quarter period over the magnetization; that is to say, it must be represented by a certain length on the line $O\, Y$. Its amount can be calculated from the formula for E_1. Let $O\, E_1$ represent it to the same scale as was used for $O\, R_1$; then the parallelogram $O\, R_1\, Et_1\, E_1$ gives us at once the point Et_1 and line $O\, Et_1$, which represents in position and magnitude the maximum electromotive force impressed on the terminals of the primary

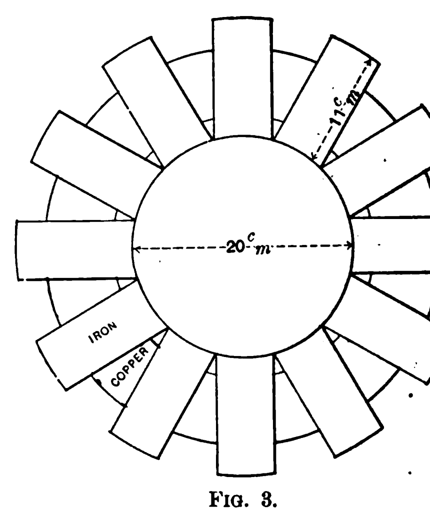


FIG. 3.

coil, and α is the angle of lag of current behind the impressed E. M. F. The work done on the primary coil is found by the well-known formula:

$$W_1 = \frac{I_1\ Et_1}{2} \cos.\ \alpha;$$

$$W_1 = i\ et_1 \cos.\ \alpha.$$

That is to say, the true work is equal to the product of the apparent work, as measured by a dynamometer and voltmeter and the cosine of the angle of lag. If the apparatus were supplied with current at a constant and undirected E. M. F. the apparent and the true work would be equal, and the ratio $\frac{1}{\cos.\ \alpha}$ indicates how much larger must be the capacity of an alternate-current plant to do the same true work as a continuous-current plant. I propose, therefore, to call cos. α the "plant efficiency" of the transformer.

It was stated above that transformers should be worked at a comparatively low induction. This might seem at first sight a retrograde step, since with dynamo machines considerable gain in efficiency and output has resulted from adopting an induction up to 20,000 and more, but by reference to figure 4, one of the reasons why a low induction is preferable will be at once apparent. Suppose that the line $O\ P$, represents the limit to which the induction

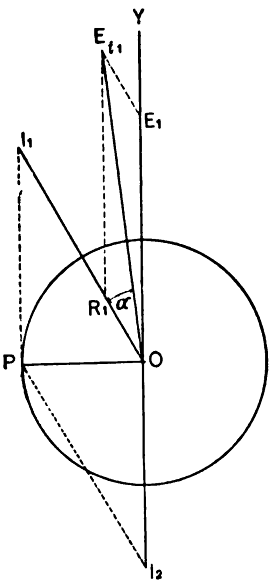


FIG. 4.

may be put without diminishing the permeability: then if the same transformer be worked at double the electromotive force, we would require an exciting power not only twice, but many times as great as previously. This would bring the point P, considerably to the left without increasing the length of the line $P\,I_1$. It would also increase the length of the line $O\ I_1$—that is, the primary current—and therefore the heat generated in the primary coil, whilst the angle of lag would become greater and the plant efficiency smaller. Similar results would follow from an increase in the magnetic resistance of the core, or from the omission of core altogether. An early type of transformer made by Messrs. Gaulard & Gibbs had no iron core, and therefore no well-defined magnetic circuit; but as the primary spirals alternated with the secondary spirals our previous assumption regarding the coefficient of mutual induction remains valid, and the above formulæ and graphic method could be applied to this apparatus if we knew what value to assume for the resistance of the magnetic field. This, however, we do not know; but the case is of no importance at present, as transformers without iron cores have become obsolete. I only mention this early apparatus because the experimental investigations of Dr. Hopkinson and Professor Ferraris[1] have proved that there is a considerable difference between the apparent and the true work; that is to say, the point P, must have been a considerable distance to the left, making the plant efficiency small In modern transformers the point P, lies so close to O, that the plant efficiency may reach as high as 99 per cent., so that the difference between real and apparent work supplied to the apparatus when giving full output becomes trifling; and for a practical determination of efficiency the readings of measuring instruments on the primary and secondary circuit may be used, with only such corrections as may be applied from the diagram.

A high plant efficiency is, however, not the only reason why transformers should be worked at a low induction. A far more important reason is the heating which takes place in the iron of the core if this be carried rapidly through cycles of intense magnetization. This heating is not due to eddy currents (although these currents in a badly designed core would produce the same effect), but seems to be the result of what may be termed dissipation of energy by molecular friction or hysteresis. The energy dissipated per cycle per cubic centimeter increases in more than simple ratio with the induction, and it seems also to increase as the periodic time decreases. As yet very few experiments have been made to determine the hysteresis for different samples of iron, the most important data published being those given by Professor Ewing and Dr Hopkinson in the *Philosophical Transactions*, part ii., 1885. Professor Ewing distinguishes between static hysteresis (slow period) and viscous hysteresis (quick period), but the experimental data refer only to the former. According to Dr. Hopkinson, the energy required to carry one cubic cenmiteter of annealed wrought iron through a complete cycle of induction equal to 18,251 lines is 13,356 ergs, and for hardened tungsten steel with an induction of 14,480 lines the energy reaches 216,864 ergs. Professor Ewing found that with very soft annealed wrought iron and $B = 13,190$, the energy dissipated by hysteresis was 9,300 ergs. He also tested annealed iron wire by carrying it through lower cycles; and, as the results are of very great importance in the construction of transformers, they are given herewith:

Induction.	Energy.	Induction.	Energy.
1,974	410	10,590	5,560
3,830	1,160	11,480	6,160
5,950	2,190	11,960	6,590
7,180	2,940	13,700	8,690
8,790	3,990	15,560	10,040

These figures refer to static hysteresis. As regards viscous hysteresis, no experiments have been made; but in the case of $B = 8,500$ and $n = 80$, Professor Ewing estimates the energy dissipated per cycle at 5,000 ergs. or 32 per cent. above that of static hysteresis. When applying the figures of the table to transformers it may therefore (until further experiments have been made) be advisable to add from 30 to 40 per cent. to the energy there given. Thus, if an induction of 18,000 be adopted, the energy dissipated would amount to 18,000 ergs per cubic centimeter per cycle; and with 80 cycles per second this corresponds to .144 watt per cubic centimeter of core. It would evidently be extremely difficult, if not altogether impossible, to provide cooling surface enough for this rapid generation of heat, and hence it is necessary to work at a lower induction, the exact amount to be determined for each transformer by the cooling surface of the core and coils, and by the heat generated in the coils themselves. So far, then, theory points to the necessity of low induction. As regards practice, I believe the makers of transformers have already found out that it does not pay to press the iron magnetically too hard. My own experience was at least in this direction. In the first transformer which I designed jointly with Mr. W. H. Snell, and which is on the table, we worked at an induction of 20,000, and there were produced two very undesirable results. In the first place, the core heated to such a degree that continuous work was out of the question; and, in the second place, the apparatus emitted a most unmusical sound, and it was evident that on this account alone it was not fit for practical use. The sound may have been partly due to the employment of wood for the framework, but we believed that the high induction was principally the cause, and by

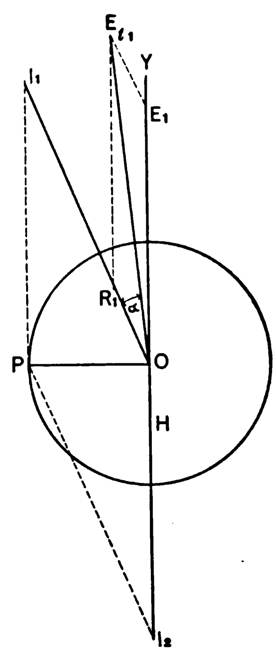


FIG. 5.

dropping the E. M. F. so as to get an induction of 15,000 we found that these evils were lessened. We then constructed another transformer, in which the induction was reduced to 10,000. This transformer is also on the table. In it the sound was suppressed, but the temperature still rose by about 30° C. when continuously at work. We have therefore, in a later design, adopted a still lower induction. Although it is possible to reduce in this manner the amount of energy dissipated in the core, this waste cannot be entirely prevented, and must therefore be taken into account when determining by the aid of the diagram the working conditions of the apparatus. For this purpose it would, strictly speaking, be necessary to know, in addition to the total energy dissipated per complete cycle, also the rate of dissipation at each point of the cycle—a knowledge which we do not possess. It

1. "Ricerche Theoriche e Sperimentali sul Generator Secondario Gaulard e Gibbs," by Galileo Ferraris. Turin, 1885.

seems, however, reasonable to assume that the rate of dissipation of energy by hysteresis follows the same law as the rate of dissipation of energy due to eddy currents—that is to say, that it is proportional to the rate of change of induction. When the induction passes through zero the rate at which the heat is generated would be a maximum, and this would gradually diminish to zero as the induction approaches its positive or negative maximum. On this assumption we can imagine eddy currents substituted for hysteresis; and in an iron core perfectly devoid of the latter property—that is, infinitely soft—the same amount of heating could be produced by imperfect subdivision, or better still, by subdividing it perfectly, but wrapping around it a closed conductor of such a resistance that the heat generated in this

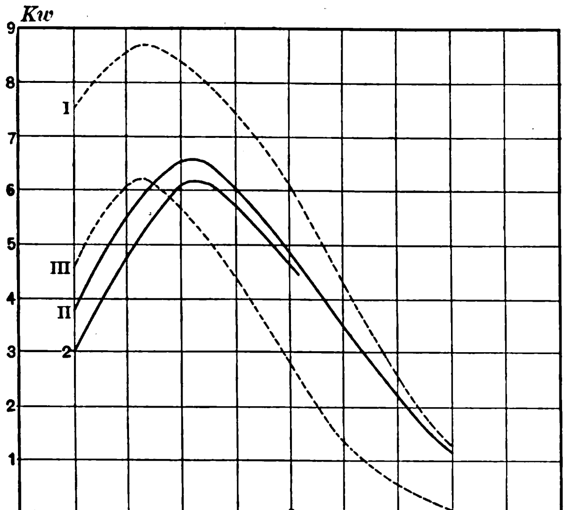


FIG. 6

conductor equals that dissipated by hysteresis in ordinary iron. For the ordinary transformer consisting of an imperfectly subdivided core of iron not infinitely soft and a primary and secondary coil, we would substitute an imaginary transformer consisting of a perfectly subdivided core of iron free from hysteresis, a primary coil, a secondary coil, and a third closed coil of suitable resistance. The current in this third coil would coincide with that in the secondary coil, and its exciting power would be added to that of the secondary coil. For example, let the volume of iron affected by hysteresis in a particular transformer be 1,000 cubic centimeters, and let the energy of hysteresis be 5,000 ergs, the total energy dissipated would, with 80 cycles per second; amount to 40 watts. If the electromotive force produced in the secondary coil be 100 volts, then our imaginary third coil would have either the same number of turns as the secondary coil and a resistance of 250 ohms, or it might have half the number of turns and a resistance of 62.5 ohms, or any other combination giving the same loss of energy. The mean value of the fictitious exciting power would in all cases be the same, namely, the number of turns in the secondary coil multiplied by .4 ampere. Let, in figure 5, $O\ H$ represent the maximum value of this exciting power due to hysteresis; then the total exciting power tending to demagnetize the core, and which must in a certain measure be balanced by the exciting power of the primary coil, is represented by the length $O\ I_2$—being the sum of $O\ H$ and $H\ I_2$, where $H\ I_2$ equals $O\ I_2$ of figure 4—and the point I_1 will be pushed higher up as compared with figure 4. The net result of this alteration is an increase in the amount of energy which must be supplied to the primary coil. It is thus possible to include the effect of hysteresis in the geometrical method of representing the working conditions of a transformer. I have dwelt at some length on this question because, notwithstanding its apparently somewhat abstruse character, it is really of very great practical importance. In some transformers the heat generated in the iron core is in excess of that generated in the copper coils, even at full output. Now where transformers are placed in parallel between high potential mains, it is, for obvious reasons of safety, not advisable to allow customers to handle a switch on the primary circuit, and the current must therefore be on, whether lamps are being lighted from the secondary or not. When the supply is continuous, as it obviously must be in a general system, the cyclic changes of magnetism in the core of every transformer will be kept up day and night, and the question of heating becomes of far greater importance than is the case in dynamo machines; which, as a rule, are only worked for a certain number of hours per day.

On the basis of the foregoing we can now investigate the relative merits of the Gramme and Zipernowski rings, and the best proportion of copper to iron in each. I have selected the two original types and one modification of each as being fair representatives of the two large classes into which, in the beginning of this paper, I have divided all transformers. These "rings" are both equally difficult to manufacture, and contain serious practical defects; but from a purely electrical point of view they are probably as good as the majority of transformers now in the market. Their practical defects constitute for my purpose a positive advantage, because nobody will care to claim either as his special type, and I shall thus escape the somewhat invidious task of having to compare the actual transformers made by rival manufacturers. As it is obviously impossible to conduct an investigation of this kind on absolutely general lines, it was necessary to assume rings of definite dimensions. I have selected rings of circular section having an internal diameter of 20 cm. and an external diameter of 42 cm., shown in full size in the wall diagrams (figures 2 and 3). The mean primary potential is assumed to be 2,000 volts, and the secondary 100 volts. The copper coils in figure 2 and the coils forming the iron shell in figure 3 are supposed to touch each other on the inside, and being of equal depth all round, to separate on the outside, exposing part of the inner ring. In the Zipernowski transformer as actually made, the inner diameter of the ring is rather smaller than shown in figure 3, and the shell winding covers the whole surface of the conductors, being of less depth on the outside than on the inside; but the magnetic resistance is in either case so low that the difference between the assumed and actual arrangement does not materially affect the result, whilst the calculations for the former are somewhat less complicated. The total space occupied by insulation I have assumed to be 1 cm. or 2.5 mm. between the core of the Gramme ring and the primary coil, and 2.5 mm. between that and the secondary coil. The same space has been allowed for the Zipernowski ring. We can now assume different sectional diameters for the inner ring (core or coils), and depth of winding for the covering (coils or shell), so as to make up the 11 cm. sectional diameter of the whole ring; and determine the output for each combination so that for continuous work the apparatus should keep moderately cool. From analogy with dynamos I estimate the total energy which may be wasted without producing overheating at 260 watts; and the output has in all cases been calculated on this basis for an induction of 8,500, a periodic time of $\frac{1}{80}$ second, and hysteresis at 5,000 ergs. As it would serve no useful purpose to burden this paper with a reproduction of the somewhat lengthy calculations, I have plotted the results in the curves II, figures 6 and 7. The curves I show the output which might be obtained if hysteresis did not exist, in which case the whole of the 260 watts would be transformed into heat within the coils. The thickness of copper winding, figure 6, and that of the iron shell, figure 7, is plotted on the horizontal; the output on the vertical. From figure 6 it will be seen that the maximum output with the Gramme ring is 6,400 watts with a

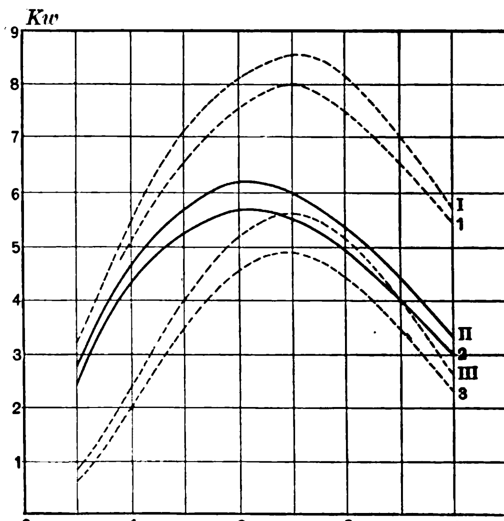


FIG. 7.

thickness of copper winding of about 1.7 cm., leaving 6.6 cm. for the sectional diameter of the core. The cross-sectional area of the magnetic circuit is in this case about 80 per cent. of the cross-sectional area of the electric circuit, and the gross volume occupied by iron is about equal to the gross volume occupied by copper. The maximum output for the Zipernowski ring (figure 7) is 6,100 watts for an iron shell 2 cm. thick, leaving the sectional diameter of the coils 6 cm. The cross-sectional area of the magnetic circuit is in this case nearly eight times that of the electric circuit, and the gross volume occupied by iron is 1¼ times that occupied by copper. Thus with the same external dimensions, the Zipernowski ring gives a slightly lower output than the Gramme ring; but it must be remembered that the weight of copper is also slightly smaller. I have made the same calculation for oblong rings, as shown in figure 8. Imagine the Gramme ring

cut in halves, these straightened and laid side by side, and the two cores joined by semicircular pieces at the ends. The copper coils will in this process not be altered, but the length of the magnetic circuit and the volume of iron in the core will be increased; hence more energy will be absorbed in hysteresis, and the output will be reduced. In figure 6 the curve 2 represents the output for the oblong Gramme ring. By adopting the oblong shape for the Zipernowski ring we do not alter the mass of iron in the shell, but we lengthen the electric circuit, and increase the waste of energy in the coils. In this case also the curve of output 2 (figure 7) must lie below that of the circular type. Curve 1 (figure 7) shows the output of the oblong type if there were no hysteresis. In figure 6 this must obviously coincide with curve I. The maximum output of the oblong type is—for the Gramme ring, a little over 6,000 watts; and for the Zipernowski ring, 5,800 watts.

Up to the present we have only considered the output as limited by the amount of energy which may be wasted without overheating. But there is another an equally important consideration which affects the output, namely, the question of self-regulation. It is evident that in a transformer fed at a constant potential the induction is a maximum when the secondary circuit is open; for in this case the counter electromotive force of the primary is very nearly equal to the electromotive force at the terminals. At full work the two differ by the amount lost in resistance, and the induction is reduced in the same proportion. The electromotive force generated in the secondary coil is proportional to the induction, and we must deduct from it the loss in resistance in order to obtain the external electromotive force. Thus, if 1 per cent. be lost by resistance in the secondary, and 1 per cent. by resistance in the primary, the difference of available electromotive force between open circuit and full output will be 2 per cent. For good lighting this may be considered the permissible limit of variation, and on this basis I have calculated

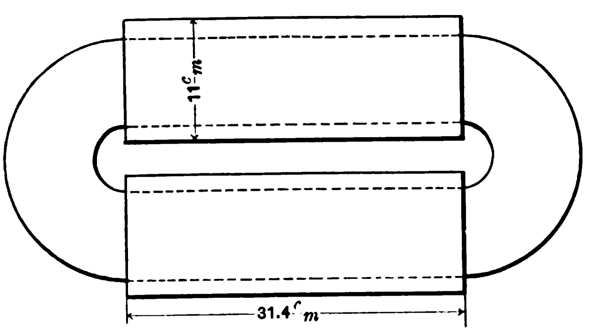


FIG. 8.

the output of the four transformers above described. Curve III in figure 6 gives the result for the circular and oblong Gramme ring. It will be seen that with a stout core the limit of output due to heating is reached sooner than that imposed by the condition of self-regulation, whilst for thin cores the reverse is the case. The best proportion of iron to copper is indicated by the intersection of curves III and II for the circular, and III and 2 for the oblong transformer. In the latter case the core would have to be 7.2 cm. in diameter, and the winding would have to be 1.4 cm. deep. The output is 5,900 watts. For the Zipernowski ring curve III gives the output as limited by self-regulation in the circular, and curve 3 in the oblong type. The diagram shows that the limit of output imposed by the condition of self-regulation is in all cases reached sooner than that due to heating. For the oblong transformer the maximum output is slightly below 5,000 watts, and the best proportion of iron to copper is given by the abscissæ of the highest point of curve 3. The external shell would have to be 2.4 cm. thick, and the sectional diameter of the coils 5.2 cm. From the above figures it appears that in the circular and in the oblong type the Gramme ring, dimensioned as shown in figures 2 and 8, gives more output than a Zipernowski ring of the same over all dimensions; the latter is therefore not superior to the Gramme ring, as commonly supposed, but somewhat inferior.

It might be, perhaps, objected that I have selected proportions different from those found in actual circular shell transformers, which have a much stouter ring of smaller mean diameter. More of the internal space is filled by the shell, and the central hole left is much smaller than shown in figure 3. The iron wire forming the shell is not put on in regular layers, but the turns cross each other in a more or less confused manner. There is no objection to such winding from an electrical point of view, as perfect insulation between the wires is of small importance. For the Gramme ring such winding would, on the other hand, be quite inadmissible; and it is on this account that I have selected a somewhat larger internal diameter of the rings, which gives room for regularly wound coils. But even if the rings are much stouter their proportion of output is not materially altered. If we imagine the ring of figure 3 contracted so as to reduce the central opening to 10 cm. and the extreme diameter to 32 cm., we obtain about the proportion of a Zipernowski transformer.

For convenience of calculation I have assumed a ring of these proportions to be changed into the oblong type, as shown in figure 8, but with this difference, that the external winding (coils or shell) on each side is only 15.7 cm. long instead of 31.4 cm.; the diameter being 11 cm., as before. Calculating the output in the same manner as before, I find that for the core transformer the maximum output as limited by heating is 3,230 watts, and is reached when the copper winding is 2 cm. deep, whilst the maximum output as limited by the condition of self-regulation (within 2 per cent.) is 3,020 watts, and corresponds to coils wound 1 cm. deep. The two curves cross each other as in figure 6, and the ordinate of the crossing point corresponds to a maximum possible output, as determined by the joint limit of heating and self-regulation, of 2,950 watts with coils wound 1.3 cm. deep. In the shell transformer the limit of output due to heating is 3,030 watts when the shell is 2 cm. thick, and the limit of output due to self-regulation is 1,650 watts when the shell is 2.2 cm. thick. These figures show that even in stout rings, having proportions more nearly comparable with those of the Zipernowski transformer as actually constructed, the core type is better than the shell type.

This result refers, however, only to transformers having a core or a shell of circular section; and the question is whether by an alteration in the form of the shell the shell transformer could be improved. Any departure from the circular form of the shell must increase the length of the magnetic circuit, and must so far be detrimental; but if we can at the same time reduce the length of the copper coils, this advantage may be more than balanced by the reduction in the resistance of the circuits. As a matter of fact, the magnetic resistance of the shell is so low that even a considerable increase in the length of the magnetic circuit does not materially affect the difference of phase between the primary and secondary current. The two are almost diametrically opposed whatever may be the magnetic resistance. We can, therefore, adopt any shape of shell which will allow the length of the copper coils to be reduced. This is actually done in most modern transformers. The shell is rectangular, with the short side of the rectangle parallel to the plane of the coils, and thus the mean diameter of the coils is reduced. In addition to this, the circular form of coils has been abandoned in several of the more modern transformers, so that the shell may fill more or less completely the interior of the coils.

In core transformers as now generally made the coils are not arranged all over the core, but are disposed of in two sets, one on each limb of a single core. Each set of coils contains a primary and secondary circuit wound upon each other, or one between the other, so as to obtain perfect symmetry. Were this not so, and were one limb wound with the primary and the other with the secondary, external poles would be formed at opposite points of the core, and the output would be reduced. In a similar manner the coils in shell transformers are wound upon or in between each other, but there is generally only one set of coils and a double core. The distinctive characteristics of the two types are therefore as follows:

Core transformers.—One core and two sets of coils.

Shell transformers.—Two cores and one set of coils.

The following are some of the principal modifications of each type:

Core transformers.—Gaulard & Gibbs, Lowrie-Hall.

Shell transformers.—Zipernowski, Ferranti, Mordey, Wright, Kennedy, Statter, Westinghouse, Snell & Kapp, Gaulard & Gibbs.

As most of these transformers are on the table, I need not describe them at length. The original Gaulard & Gibbs transformers had an open magnetic circuit, and cores which could be more or less inserted into the coils so as to regulate the E. M. F. of the secondary, a provision obviously necessary where the transformers are coupled in series. In the apparatus shown in 1883 at the exhibition in the Aquarium, there were four distinct induction coils; and in that employed for lighting on the Metropolitan Railway in 1884 there were 16 distinct induction coils, the circuits being formed by a compound cable consisting of a central primary wire and six secondary wires grouped round it. In 1885 was introduced a type of transformer with closed magnetic circuit. In the same year Messrs. Gaulard & Gibbs introduced small shell transformers in their Tivoli installation, each transformer feeding one 50 c. p. lamp. The two circuits are formed by a compound cable coiled into a solenoid, through which is passed a bundle of iron wires; the projecting ends are then bent over to close the magnetic circuit on the outside of the solenoid, and the whole is encased in a perforated metal cylinder with wooden ends. In their latest design of transformer the coils are circular in plan and rectangular in section, and are surrounded by groups of U-shaped soft iron stampings slipped over from both sides and held together by two circular cast-iron plates with a central bolt. The primary circuit is split up into two coils, with the secondary between them.

In the Lowrie-Hall transformer there are two sets of primary and secondary coils laid horizontally one above the other. The core is formed by thin broad sheets of soft iron insulated from each other by varnished calico, and the projecting ends of these

plates are alternately bent up and down respectively so as to complete the magnetic circuit, the whole being clamped together in a horizontal cast-iron frame. The Ferranti transformer is similar in the mechanical arrangement, but, belonging to the shell type, has only one set of coils of rectangular section. The core is formed of thin iron strips of moderate width insulated from each other, doubled over at the ends, and clamped in a cast-iron frame. Mr. Rankin Kennedy has devised various transformers of the shell type. For the general supply of alternating currents he proposes to use a main current transformer at the generating station, in which currents from low tension dynamos are to be converted into high tension currents to be sent into the mains. The shell of this transformer is built up of moderately wide but very thin strips, to form a rectangular frame of considerable depth, the strips being fastened by bolts at the corners. The core is composed of a series of strips of double width passing like a web through the middle of the opening of the rectangle, and thus subdividing it into two openings through which the winding passes. In another type, which Mr. Kennedy calls the "Piled Form of Subdivided Transformer," the iron portion consists of **H** stampings, in which the central web forms the core and the two down strokes of the **H** the shell, the coils being wound over the web. A number of these wound frames are piled upon each other, and side by side, the whole being clamped between cast-iron covers. Diagramatically, this construction can be represented by figure 1 if, instead of employing only two links, we use a number of them formed into a chain consisting alternately of copper and iron circuits. In another form of apparatus Mr. Kennedy uses a Siemens shuttle armature overwound with a shell of iron wire. Mr. Wright's transformer may be described as a Zipernowski ring with coils of rectangular section and a shell of rectangular iron frames instead of the original iron winding. Each frame is cut across a corner, so that it may be placed over the core; and as the edges are packed close on the inside, but radiate on the outside of the ring, the frames form gills for the dissipation of heat. In Mr. Mordey's transformer the shell consists of thin rectangular iron plates with a rectangular opening, the strip cut out being laid across the frame to form the core of the coils. The ratio in the length of the sides of the rectangle must evidently be as 4:6, and that of the strip cut as 2:4, in order to obtain a uniform section throughout the magnetic circuit. The apparatus is built up by alternately slipping a frame over and a strip through the coil. The core of the Westinghouse transformer consists of rectangular frames, each with a central web connected to the frame on one side only, so that it can be bent back to slip over the coils. The whole is mounted in a cast-iron weather-proof box for outdoor use. The shell in Mr. Statter's transformer consists of **E**-shaped stampings slipped over the coils alternately from either side. To obtain the same area of iron throughout, the width at the bottom of the stamping is twice that of the limbs. In the transformer designed by Mr. Snell and myself, the shell consists of **U** stampings forming a double trough into which the coils are laid. The covers of these troughs are formed from the metal removed from the interior of the stampings. The whole is held together in a cast-iron frame so arranged as to allow air to circulate through the core and round the coils.

To render transformers perfectly safe it is necessary to avoid leakage between the two coils. For this purpose Mr. Kent has devised a very simple apparatus, consisting of an insulated sheet of metal wrapped round the inner of the two coils, but not forming a closed circuit in itself. This sheet of metal, which thus separates the two coils completely, is connected to earth. Now, if the insulation of the primary coil should fail, the leak before reaching the secondary coil, must pass through the sheet of metal, and is thus conducted to earth, causing the primary cut-out to melt, and thus cutting the faulty transformer out of circuit. Another safety appliance has been devised by Captain Cardew. Its object is to disconnect the primary circuit from the mains if any part of the secondary circuit acquires a certain potential above that of the earth, which will take place if a leak occurs between the two circuits. The apparatus consists of a cast-iron box on the bottom of which is laid, into a shallow recess, a strip of platinum foil terminating at both ends in circular discs. About one-eighth of an inch clear above one of these discs is set a metal disc with screwed stem at the back passing through the glass cover of the box, and connected by a fine fuse wire with any point of the secondary circuit. The box itself is connected to earth. The fuse wire holds back a contact spring so arranged that on breaking of the wire it will fly down to its contact and short circuit the primary terminals of the transformer, after which its own primary fuse will melt and cut off the supply of current. If the potential between earth and the insulated disc in the box should rise above a certain limit (which can be regulated by screwing the disc up or down) the static attraction between the disc and aluminium foil lifts the latter into contact, allowing a leakage current to pass through the fuse wire of the contact spring, and thus releasing the latter. I am told by Captain Cardew that this apparatus has been tried at the Grosvenor Gallery installation, and been found to act in a perfectly reliable manner.

In the present paper I have only dealt with what may be called elementary principles in the construction of transformers. As, however, the application of transformers is a matter of far greater importance to our profession at large, I trust you will allow me to say a few words on this subject, not with the object of imparting information, but in the hope that a discussion of real practical value may be the result. Up to the present, distribution by transformers has been made either on the single-series or the single-parallel system; compound parallel, the three-wire system, or any other refinement of direct supply methods, have, to my knowledge, never been attempted with transformers. The series system must fail for want of self-regulation where the lamps are to be connected in parallel and controlled independently of each other; but for very extensive and sparsely lighted districts, with the lamps supplied by each transformer in series on the Bernstein system, a series arrangement of transformers will admit of perfect self-regulation, provided the primary current be kept constant, and will, moreover, be cheaper than the parallel system. For general purposes, and especially for the dense lighting required in towns, the only practical method at present in use is to connect the primary terminals of the transformers all in parallel, and the lamps also in parallel, across the secondary circuit of each transformer. In principle this arrangement is adopted in England, America, and on the continent; but the methods differ in these countries. Here the distribution is made by a high-tension network of mains, and the transformer of each subscriber is directly connected with the mains. In America a double network of overhead mains is employed, one for the high tension and the other for the low tension currents. These mains are supported generally on the same poles, to which are also fixed the transformers, and the subscriber's connection is made with the low tension mains wherever convenient. On the Continent a network of low tension underground mains is used for distribution in the same way as if the supply were on the direct system, and this network is fed by alternating currents at certain points where fairly large transformers are installed. The primaries are connected with the station either by overhead wires or by a special kind of cable containing two circuits insulated from each other and arranged concentrically. The cable is protected by a double lead covering and by an iron sheath formed of spirally wound tape. Of the three methods here described our own appears to be the worst, the American slightly better, and the Continental the best. To string high tension wires over and across our streets, allow high tension branch leads to pass into our houses, and give every subscriber a little transformer to himself, more or less within reach of the inmates, seems to me to be positively courting disaster. Such rough-and-ready methods may do as long as the light is not generally installed throughout a district; but once assume that every householder is using it (and it is that we are hoping for), the thousands of branch wires and transformers in the houses must constitute a very serious element of danger. In the American plan the high tension wires are not brought into the houses, and in so far there is little danger to the inmates; but of course in the streets there is the same danger as here from overhead wires.

Now the Continental plan may almost be called absolutely safe. With an arrangement like Mr. Kent's dividing sheet to prevent leakage, or Captain Cardew's ingenious apparatus for detecting it and cutting off the supply, the secondary circuit can never acquire a potential sufficiently high to endanger life or property. This network can be composed of comparatively light cables, because we can feed it at frequent intervals, and thus insure constancy of pressure at all places and at all hours. The transformers would be fairly large—say from 500 to 1,000 lights each—and could be installed in rooms to which no person but the authorized attendant has access; and by placing the primary feeding mains also underground accidents would be rendered almost impossible. The method of using an underground secondary distributing network has also the advantage that, should at any future time storage batteries become sufficiently improved to render distribution by continuous currents possible, the whole of the cables would be available for this purpose without any change.

THE COMPARATIVE VALUE OF THE CONTINUOUS AND THE ALTERNATING CURRENT SYSTEMS FOR THE COMMERCIAL DISTRIBUTION OF ELECTRICITY.[1]

BY H. WARD LEONARD.

THERE exists to-day a great deal of uncertainty in the minds of many persons interested in the distribution of electric energy as to the comparative value of the continuous current three-wire system and the alternating current converter system; and as the published statements relative to these two systems have apparently greatly exaggerated certain advantages and disadvantages of the one system and the other, I will endeavor to institute what I consider as fair a comparison as possible between the two systems, using the best data at my command, and giving due weight

1. Abstract of a paper read before the Chicago Electric Club.

to the several factors necessary in a general system for the distribution of electric energy on a commercial scale.

In considering the comparative value of these two systems, let us compare them with each other upon the following points, which I consider the vital ones in a general supply system of electric energy.

First. First cost.

Secondly. Economy, efficiency and depreciation.

Thirdly. Reliability.

Fourthly. Variety and value of the possible sources of revenue.

Fifthly. Safety to life.

Sixthly. Effects upon existing property.

First Cost and Economy.—This is a feature which is subject to variations which are not similar in the two systems, and it may be well to give some general explanations of the cause. In a three-wire system the principal items of cost are the generators, main conductors and inside wiring. In the alternating system the main items of cost are generators, primary circuit, converters and secondary circuit.

The cost of the generators is, as far as I am able to judge by inspection and comparison of prices, about the same. At any rate, any possible difference in this respect must necessarily be but slight in its influence on the total cost of which it becomes a very small factor. We, therefore, come to a comparison between the cost of the feeders, mains and inside wiring of the three-wire, and the cost of the mains, converters and inside wiring of the alternating system.

The cost of the conductors transmitting a given amount of energy at a given loss for a given distance varies, generally speaking, inversely as the square of the initial electromotive force employed. For instance, if the E. M. F. of one system be 1,000 volts, and that of another be 110 volts, the cost of conductors for the latter under similar conditions would be to the cost of the former as 1,000,000 ($1,000^2$); 12,100 (110^2); *i. e.*, as 82: 1.

In the three-wire system double the E. M. F. of the lamps is used, and the practical effect is the same as if the lamps were operated in series as far as the two outside conductors are concerned.

We saw that the cost of a conductor for a 110 volt two-wire system and a 1,000 volt converter system was as 82 is to 1. It is now evident that by using the three-wire system this ratio becomes as 27.5 is to 1.

The three-wire system is not, of course, limited to the electromotive force quoted. The Edison company operate dynamos of 1,200 volts in a three-wire system for their municipal system.

The standard three-wire system of to-day is limited by the difficulty in manufacturing lamps of much higher voltage than 110. When the time comes, and it seems near at hand, that lamps can be had of double the voltage of those, the cost of conductors of the three-wire system will be one-fourth of what it is to-day; or, in other words, existing conductors will be able to supply four times as many lamps as at present, and at the same loss; also, an increase in the economy of the incandescent lamps would reduce the cost of conductors proportionately, and we can, of course, expect to see very great improvements in this direction.

It is evident, therefore, that the cost of conductors in the three-wire system will be reduced by inevitable improvements in the lamp itself to but a small fraction of its present cost.

Now let us look at the alternating system under similar conditions. Outside of the generator the converter is the principal item of cost, the cost of conductors being slight in comparison, as we will see later. An increase in the voltage of the lamps would be of no benefit whatever, and an increase in the economy of the lamps would result in a proportional reduction in the cost per lamp. Let us suppose that the voltage of existing lamps be doubled, and the economy increased 25 per cent., both of which results are likely to be seen in a very few years, if not sooner. The cost of conductors for the three-wire system would be reduced 80 per cent., and the cost of converters would be reduced 20 per cent., or, in other words, existing three-wire conductors would be able to supply five times as many lamps as at present, an increase in capacity of 400 per cent., and existing converters would be able to supply 25 per cent. more than at present.

So much for the probable reduction in first cost consequent upon improvements in the economy of the lamp itself, the only place in any incandescent system where much increase in economy can be expected, as existing devices are all claimed to have, and most of them do show an individual efficiency of 90 per cent. and upwards.

Let us now examine the comparative cost, as these systems exist to-day. In order to do this, it becomes necessary to determine the cost of conductors under the varying conditions met with in practice; and this can be conveniently done by applying the following formula deduced by the writer, the accuracy of which has been tested by practical use for about two years:

Let *T. C. P.* be total candle-power.

Let *D* be the mean distance current travels (one way).

Let *L* equal price per pound of copper (in cents).

Let *V* be volts lost in conductors (both ways).

Let *E* be E. M. F. of lamps.

Let *C. H. P.* be candles per electrical horse-power.

$$\text{Then } \$ \quad \frac{T.\,C.\,P. \times D^2 \times L}{V \times E \times C.\,H\,P. \times 1{,}000}$$

For the three-wire system, one third of this value is to be taken.

Before proceeding to apply the formula, let us clearly understand that with a continuous current the loss in conductors is

exactly proportional to the amount of energy they transmit; *i. e.* any variation in the load causes a proportional variation in the loss in conductors.

With the alternating current this is not the case, the decrease in the energy transmitted resulting in but a slight decrease in the current. Thus, with a continuous current the loss in conductors under conditions of one-quarter load is one-quarter what it is at full load, but with the alternating current the loss in conductors at one-quarter load is probably 75 per cent. of what it is at full load. However, as this conclusion is based mainly on theoretical grounds, I will, in comparison, grant that the alternating current will be as efficient in this respect as the continuous current.

Careful examinations of the load diagrams of some 50 Edison central stations, show that throughout the run the average load is from 33 to 40 per cent. of the maximum load; *i. e.*, if the loss in conductors is 10 per cent. when the full load is on, the average loss throughout the whole time the plant is supplying light is but 4 per cent.

Table I shows the maximum loss expressed in volts, the corresponding maximum per cent. of loss, the corresponding average per cent. of loss, and consequently the average efficiency of the system of conductors:

TABLE I.

System.	Three-wire system.			1,000 volt alternating current system.		
Maximum loss in volts	12.5	20	30	25	50	100
Maximum loss in per cent	10	15	20	2.5	5	10
Average loss in per cent	4	6	8	1	2	4
Average efficiency	96	94	92	99	98	96

These two tables show the individual efficiency of the different portions of the two systems, and the total efficiency from the driving belt up to and including the portions named. I have granted in all cases for the converter system an efficiency of 98 per cent. for the primary, and 99 per cent. for the secondary conductors. With a commercial efficiency of 90 per cent. for the generator and 95 per cent. for the converter, which is sometimes claimed for them by some, the total efficiency is 82.9 per cent. With a commercial efficiency of 85 per cent. for the generator and 90 per cent. for the converter, which is believed by others to be liberal, the total efficiency is 74.2 per cent. In the three-wire system we have assumed an efficiency of the generator of 92 per cent., which result is obtained by every maker of a first-class dynamo of this type, and an efficiency of 99 per cent. for both the mains and the inside wiring, both of which portions of the system are in practice calculated for a maximum loss of 2 per cent.

The maximum loss in the feeders in table number 2 is made 10, 15 and 20 per cent., with a corresponding average loss of 4, 6 and 8 per cent., and an efficiency of 96, 94 and 92 per cent.

TABLE II.

Alternating current converter system.

—	Indv.	Total.	Indv.	Total.	Indv.	Total.
Efficiency of generator	90	90	88	88	85	85
Efficiency of feeder	98	88.2	98	87.2	98	83.3
Efficiency of converter	95	83.8	92	79.3	90	75
Efficiency of services and inside wiring	99	82.9	99	79.5	99	74.2

Three-wire system.

—	Indv.	Total.	Indv.	Total.	Indv.	Total
Efficiency of generator	92	92	92	92	92	92
Efficiency of feeder	96	88.2	94	86.5	92	84.6
Efficiency of mains	99	87.3	99	85.6	99	83.7
Efficiency of services and inside wiring	99	86.5	99	84.7	99	82.9

Assuming the highest efficiency claimed for the alternating current generator, and assuming the generator is as efficient as a continuous current generator under conditions of partial load—which is not likely—and assuming that the converter has the same efficiency under partial load as under full load—which we know cannot be—we still are met with the fact that the three-wire system with a maximum loss of 20 per cent. in the feeders has as high an efficiency as the converter system, allowing it every possible claim, and that the three-wire system as usually installed, with a maximum of 10 per cent. loss in feeders, has a superior efficiency of from 4 to 12 per cent. over the alternating current converter system.

To return now to the question of first cost. Assuming the cost of copper at 16 cents per pound, I have figured the cost of copper conductors for feeders for 16 candle power, 50 watt lamps for distances of 1,000, 2,000, 3,000, 4,000, 5,000 and 6,000 feet, with an average loss in conductors of 4, 6 and 8 per cent. for the three-wire system, and 2 per cent. for the alternating system with 1,000 volts initial E. M. F.; cost is expressed in dollars and decimal fractions thereof.

TABLE III.

Cost of copper for three-wire feeder per 16 c. p. lamp (50 watts, 110 volts). Copper at 16 cents per lb.

Distances	1,000	2,000	3,000	4,000	5,000	6,000
12.5 volts maximum loss equals 5 volts average loss, which is 4 per cent	.266	1.064	2.394	4.256	6.65	9.576
20 volts maximum loss equals 8 volts average, which is 6 per cent	.1615	.646	1.453	2.584	4.037	5.812
30 volts maximum loss equals 12 volts average, which is 8 per cent	.1077	.430	.969	1.723	2.69	3.87

Cost of primary and secondary circuits and converters for 1,000 volt alternating current converter system, per 16 c. p. lamp, at varying distances.

Distances	1,000	2,000	3,000	4,000	5,000	6,000
Primary	.0213	.065	.191	.340	.530	.764
Converter	3.000	3.000	3.000	3.000	3.000	3.000
Secondary	.240	.240	.240	.240	.240	.240
Total	3.2613	3.325	3.431	3.580	3.770	4.004

I have also calculated the cost of copper in the mains for one 16 c. p. lamp on the basis of a distance of 800 feet between feeder terminals in the three-wire system and a maximum loss of 2 per cent. and find it to be 13 cents. Also the cost of services and inside wiring in the three-wire system on basis of an average distance to lamps of 100 feet, and 2 per cent. loss, and since the full benefit of the three-wire distribution cannot be attained in the inside wiring, have assumed the saving of one-third over the two-wire system instead of the two-thirds saving effected in cases where the full benefit can be attained. On this basis the cost of copper for services and inside wiring is six and one-half cents per lamp.

In the alternating current converter system I have assumed the cost of converters recently quoted by Mr. Stanley, the electrician of the Westinghouse company, in a paper before the Boston Society of Arts. This figure is three dollars per lamp. I have calculated the cost of copper per 16 c. p. 50 volt and 50 watt lamp with an average distance to the lamp of but 75 feet, and with 2 per cent. loss, and found the cost of copper to be 24 cents per lamp. With an average distance of 100 feet, as was assumed in the case of the three-wire system, the cost of conductors for the inside wiring would be 43 cents. In making the comparisons, however, we will give them the advantage due to the 75 feet distribution; that is, 24 cents per lamp.

I have plotted these results, expressing cost as ordinates, and distances as abscissæ. The curves resulting are here shown. See diagram.

In the diagram curve No. 1 shows cost of primary converter and secondary for alternating system (converters at $3 per lamp).

No. 2 shows cost of primary and converter for alternating system.

No. 3 shows cost of primary for alternating system.

No. 4 shows cost of feeders for average loss of 4 per cent.

No. 5 shows cost of feeders for average loss of 6 per cent.

No. 6 shows cost of feeders for average loss of 8 per cent.

No. 7 shows cost of feeders and mains for average loss of 9 per cent.

No. 8 shows cost of feeders and mains in the three-wire system for average loss of 6 per cent.

No. 9 shows cost of feeders and mains in the three-wire system for average loss of 8 per cent.

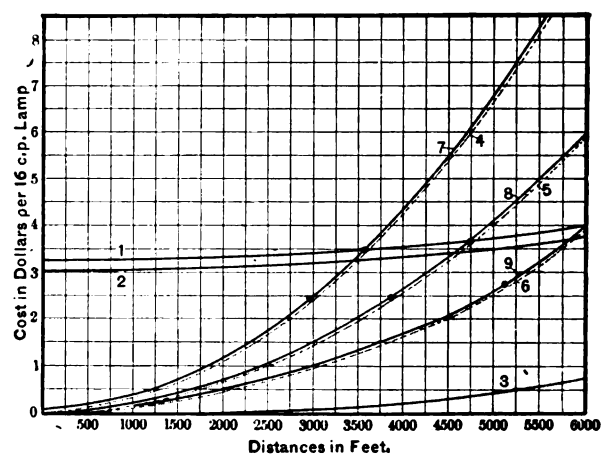
In the three-wire system curves for total cost are the lines in black just above the dotted lines.

It will be seen that if the three-wire system be operated at an average efficiency of 92 per cent. in the feeder, which corresponds to the highest efficiency claimed for the alternating current converter system, the total cost per lamp would be equal when the average length of feeder was 6,000 feet. An average length of feeder of 6,000 feet corresponds to a circular area 18,000 feet in diameter—that is, about 3½ miles in diameter. In practice, it is preferable to operate at higher efficiency, making a large investment in copper, which has the strong recommendation of having the least depreciation, and requiring the least attention of anything used in connection with the transmission of energy.

The middle curves represent an average efficiency of 94 per cent. in the feeder: that is, an average loss of 6 per cent. in the feeder. You will notice that even with this superior efficiency the three-wire system is cheaper per lamp than the alternating current converter system at an average length of feeder of 4,750 feet, corresponding to a circular area of 12,000 feet in diameter, and that for shorter distances the cost rapidly diminishes—the cost of conductors for three-wire system at this efficiency with an average length of feeder of 3,000 feet corresponding to a circular area 9,000 feet in diameter, being less than one-half the cost of conductors and converters for the alternating system.

Even with the very high efficiency of 96 per cent. in the feeder, or an average loss of but 4 per cent., the conductors of the three-wire system are cheaper than the conductors and converters of the alternating current converter system for an average length of feeder of 3,600 feet or less, and this corresponds to a circular area 11,000 feet in diameter.

Suppose that both the generator and converter are so much cheaper than we have assumed as above that it makes a total



reduction of $1 per lamp. We then find that under conditions of equal efficiency, 82.9 per cent., the three-wire is cheaper where the average distance to lamps is one mile or less. With the usual efficiency for the three-wire system, 84.7 per cent., it is the cheaper for an average distance to lamps of 4,000 feet, or less, and with the highest efficiency, that is 86.5 per cent., with average loss of 4 per cent. in the feeders, the three-wire system would be the cheaper when the average distance to lamps is 3,000 feet or less.

Suppose, on the other hand, that the incandescent lamp be doubled in voltage, and increased 25 per cent. in economy; at the same time that the cost of converter was reduced to two-thirds its present cost, and we find that with the highest efficiency, 96 per cent. in the feeders, the three-wire system would be the cheaper for cases where average distance to lamps is 8,000 feet or less, which corresponds to a circular district about five miles across.

Before leaving the question of economy of operation, let us look at the question of depreciation. In any dynamo the depreciation naturally becomes greater when it is operated at high E. M. F., even where the type is the same, and in the high E. M. F. alternating current generator there exists the greatest tendency toward troubles due to the breaking down of the insulation of the wire on the armature. The secondary circuit of the alternating current system and the inside wiring of the three-wire system would have a similar depreciation, but there is a great difference between the depreciation of copper conductors carrying low E. M. F. continuous currents and the depreciation of highly insulated conductors carrying a high E. M. F. alternating current, together with the depreciation on an expensive piece of apparatus like the converter, the large proportion of the cost of which is represented by labor. Try to compare the value of copper 20 years hence which costs $1,000 to-day with $1,000 of converters, and small highly insulated wire such as is used in the primary circuit of the alternating system, and I think it will be evident that the depreciation of the alternating system is going to be many times that of the three-wire system.

THE DEVELOPMENT OF THE MERCURIAL AIR PUMP.[1]

BY PROFESSOR SILVANUS P. THOMPSON, D. SC., B. A.

(Continued from page 58.)

In 1881, Mr. Rankin Kennedy[2] prepared a pump for exhausting lamps, going back in principle to that of Baader. Mercury is passed down a supply tube, S (figure 16), and rises with the pump-head, expelling the air through a valve, V. Then a three-way eject tap, E, at the bottom is turned, cutting off communication with S, and allowing all the mercury in the pump-head to run out into a basin below. The lamp, or other vessel, R, to be exhausted, is joined in through an aperture at the top of the pump-head by means of a tube passing in through an India-rubber cork, *c*, and sealed above by a mercury joint. This tube is also supplied with an automatic valve, *v*, at its lower end, to allow it and the exhausted lamp to be removed from the pump, in order to seal it off. A similar device had also been described by Akester. Akester's pump[3] closely resembled that of Lane-Fox; but in it the raising and lowering of the supply vessel was obviated by using, at the bottom of the pump-shaft, a three-way tap, enabling the barometric column to be placed alternately in communication with a supply cistern placed at a high level, and with a return pipe through which the descending mercury flowed away at a lower level, to be again pumped up to the high level by a me-

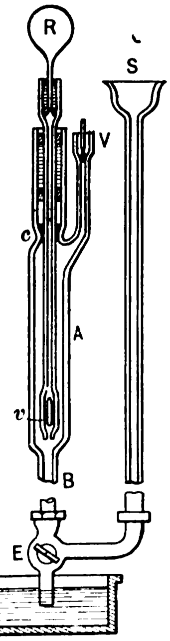


Fig. 16.

Kennedy's Pump.

chanical pump. Another way of raising and lowering the mercury in the pump, which also dispensed with flexible tubing, was suggested by Rock.[4] (A similar device was suggested by Mile in 1830.) The pump-head and barometric column are formed by a single straight cylindrical tube, about 100 centimeters long, 10 centimeters in internal diameter of glass, and one centimeter in thickness. It is open at the bottom, but closed in and furnished with the usual three-way tap at the top. Outside it is a second, slightly longer, tube, having an internal diameter of 12.6 centimeters. This—the supply vessel—is closed at the bottom, and can be raised or lowered mechanically. If the outer one, filled with quicksilver, is raised, the liquid forces its way up the inner tube, driving the air before it, through the three-way tap. When it is lowered, the mercury remains inside, to a height which will never exceed 76 centimeters above the level of the mercury in the outer tube, the space above being left vacuous. The inventor claims that this construction is less liable to give trouble than the usual form. Cruto[5] has used a somewhat similar device, but with sulphuric acid instead of mercury in the pump. To obviate having to work with a pump shaft 20 feet long, he adopted the device of an auxiliary exhaust pump. Narr[6] has described a simple pump on Jolly's plan, but having steel taps, the pump head of glass having united above and below to the working parts by carefully ground and lightly greased steel unions, clamped together by screws. By reason of its strength, this construction seems to be preferable in cases where very high vacua are not required.

Double-action pumps have been suggested by various persons. Kemp's pump (figure 8) was of this class, so is one by Serravalle,[7]

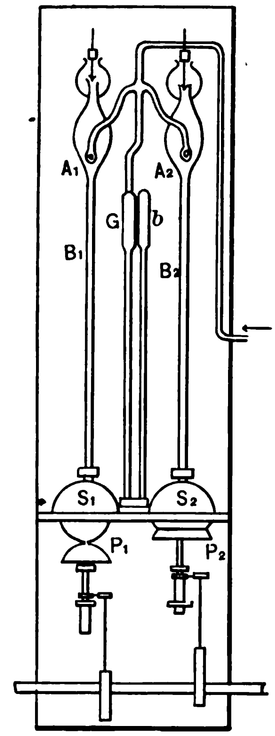


Fig. 17.

Gardiner's Double Pump.

in which there are two supply vessels, so arranged that while one rises the other descends; two separate pump-heads, with two three-way taps automatically opened and shut; and two exhaust tubes uniting into one. Another double pump, by Gardiner,[8] de-

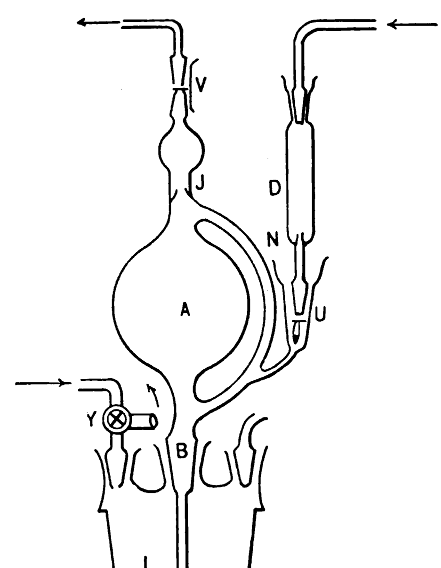


Fig. 18.

Schuller's Pump.

picted in figure 17, is worked mechanically from a rotating shaft. Two eccentrics drive alternately up and down two hemispherical

1. Read before the Society of Arts, London (Eng.), Wednesday, Nov. 28.
2. Kennedy. Specification of Patent, 5,524, of 1881. See also Dredge's "Electric Illumination," ii., p. 232.
3. Akester. See Specification of Patents 4,458, of 1881, and 2,519, of 1882.
4. Rock. "Wied. Beibl," vii., 790, 1883.
5. Cruto. Specification of Patent, 1895, of 1882.
6. Narr. Ueber eine Abänderung der Jolly'schen Quecksilber-luftpumpe. "Wied. Annalen," 548, 1885.
7. Serravalle. "Riv. Scient. Industr.," xiv., 401, 1882; also "Wied. Beibl," vii., 490, 1883.
8. Gardiner. See "La Lumière Electrique," xiii., 219, 1884.

pistons, P_1, and P_2, which press in the flexible hemispherical bottoms of the two supply vessels. The valves of this pump are all automatic, as in Kemp's pump. It is provided with a barometric gauge, G, and a comparison barometer, b. This pump was in use for some time at the Gülcher company's works at Battersea.

SUB-CLASS Ia.—SHORTENED UPWARD-DRIVING PUMPS.

The length of the pump-shaft in the preceding cases being necessarily equal to that of the barometric column, renders all these forms of apparatus more or less unwieldy. Although a column of mercury 76 centimeters high is a necessity for working between vacuum within and atmospheric pressure without, no such length is required when working between vacuum and a reduced pressure. In fact, the length of the pump may be shortened by reducing the pressure of the air above the surface of the mercury in the supply vessel, in all pumps of class I. and class II. The first suggestion for shortening the pump came from the Rev. Professor Robinson,[1] in 1864, and was almost immediately followed by one from Professor Poggendorff.[2] In these apparatus a common air-pump worked by hand was used to produce a partial vacuum. The pump-shaft was quite short, and ended in an auxiliary chamber, closed at the top, but having a tap communica-

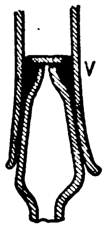


Fig. 19.

Detail of Valve.

ting either with the auxiliary pump or with the outer air. The three-way tap above the pump-head also opened into a tube which could be made to communicate either with the auxiliary pump or with the outer air. To fill the pump-head with mercury, air was admitted to the auxiliary chamber, whilst at the same time the auxiliary pump was applied at the top to suck the mercury into the pump-head. The three-way tap being then turned to put the pump-head into the vessel to be exhausted, the auxiliary pump was used to reduce the pressure in the auxiliary chamber, causing the mercury in the pump-head to fall, the height of the column representing always the difference between the pressure in the pump-head and that in the chamber.

Several later experimenters have adopted this device of applying an auxiliary pump to shorten the vacuum pump; and as we shall see, the device is applicable to each of the three main classes of pumps. Dr. F. Neesen,[3] whose more recent pump is described later, adopted this device in 1878. At that date he was employing a shortened Geissler pump, to which, independently of Mitscherlich, he had applied an automatic exit-valve above the pump-head. He had also introduced another notable improve

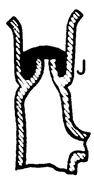


Fig. 20.

Schuller's Mercury Valve.

ment, namely, a side-tube, connecting the exhaust-tube from a point a little beyond where it branched off from the pump-shaft to a point above the pump-head below the automatic valve. Such a side-tube, marked N, in the figures 18 and 33, prevents the fracture of the top of the pump-head by air bubbles suddenly rising through the mercury in the barometric column.

Schuller,[4] in 1881, described another shortened pump, with numerous carefully considered details, and a curious automatic method of operating, which, however, need not here be described. Figure 18 shows Schuller's pump. V and U are automatic valves consisting of small pieces of flat glass, preferably triangular, which close the mouths of tubes that have been also carefully ground flat. In the valve V, shown in detail in figure 19, the weight of the small glass plate is partly sustained by the ring of mercury surrounding the tube end above which it lies.

Another feature of Schuller's pump is the valve J, situated in the tube between the pump-head and the upper valve V. This valve J, shown larger in figure 20, is composed wholly of mercury, which, during the descent of the body of liquid down the tube, forms, by virtue of its great surface-tension, a cap over the orifice three millimeters in diameter, which is here interposed. As in Geissler's later pumps, there is an auxiliary chamber, M, between V and J, in which a partial vacuum is formed, so that the residual air expelled from the pump-head is driven into an already exhausted space. The little vault of mercury over the aperture in J, is able to withstand the difference of pressure between the partial vacuum above and the nearly perfect vacuum below it. At the commencement, a partial vacuum is made in the pump-head, through the upper valve, by an auxiliary mechanical pump. A three-way tap, Y, suffices to put the space in the bottle, L, alternately into communication with the atmospheric air, and with a tube leading to an auxiliary mechanical air pump.

Another pump of this class, by Dittmar,[5] has simply two plain glass taps, one above, the other in the exhaust tube at the side of the pump-head. It obviously could not give a good vacuum.

The most recent pump in this category appears to be that of M. A. Joannis.[6] The ordinary three-way tap at the top of the pump-head communicates with the open air; below, at the lower end of the pump shaft, is a closed vessel, communicating by another three-way tap with a water aspirator, and with a source of pressure by means of which the mercury is alternately raised and lowered.

CLASS II.—DOWNWARD-DRIVING PUMPS.

The idea of expelling the residual air down a barometric column originated with Dr. Hermann Sprengel,[7] who in the year

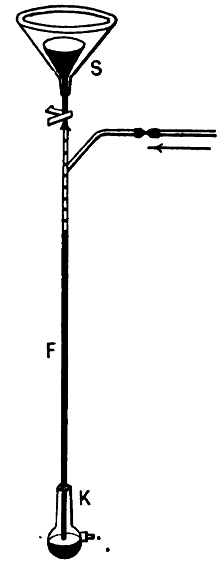


Fig. 21.

Sprengel's Pump. (Simple Form.)

1865 brought out the pump which is associated with his name. He had in the preceding years been studying the uses in the laboratory of the water trombe or aspirator, a much older instrument, used for some hundreds of years for delivering air under pressure. The theory of this ancient apparatus had already received the attention of Magnus,[8] and of Buff,[9] and Sprengel[10] had himself devoted some attention to this method of furnishing air for the blow-pipe. It appears to have been an original idea with him to substitute falling mercury in the place of falling water, in order to extract gases by means of the vacuum produced above the column.

The form of the original Sprengel pump is shown in figures 21 and 22. The supply vessel S, was, in this case, a funnel fixed at the top of the apparatus, from which the mercury was delivered at a steady rate through a narrow India-rubber tube, nipped by an adjustable pinch-cock. After passing this point it fell in drops down a glass tube, F, of narrow bore, but having strong external walls, and known as the fall-tube. As it fell down this tube in

1. T. R. Robinson. "Description of a New Mercurial Gasometer and Air-pump. "Proc. Roy. Soc.," xiii, 321, 1864. *Phil. Mag.*, xxviii., 235, Sept. 1864.

2. Poggendorff. "Pogg. Ann.," cxxv., 151, 1865. See also Müller-Pouillet's "Physik" (1876), i., 233.

3. Neesen. "Wied. Ann." iii., 608, 1878; also "Zeitschrift für Instrumentenkunde," ii., 287, 1882.

4. Alois Schuller. "Wied Ann.," iii. 528, 1881.

5. Dittmar. See "Challenger Report: Physics and Chemistry," vol. i., 1884; plate 3.

6. Joannis. Modification de la machine pneumatique à mercure. "Ann. Chim. Phys." Series VI., xi., 285, 1887.

7. Sprengel. "Journ. Chemical Soc.," Series II., iii., 9, 1865; see also Pogg Ann.," cxxix., 564, 1865

8. Magnus. "Pogg. Ann.," lxxx., p 32, 1850.

9. Buff. "Ann. der Chem. und Pharm.," lxxix., 249, 1851.

10. Sprengel. "Pogg. Ann.," cxii., 634, 1861.

drops, it swept out the air of the tube and the air which entered from the side, each drop acting as a piston to propel the air below it. To secure this action, it is essential that the fall-tube should not be too wide. For rapid, partial exhaustions, an internal bore of two to three millimeters appears to be about the best size; for slower exhaustions, carried to the highest degree of rarefaction, a bore of 1 4 to 1.8 millimeters appears to be preferable. During the first stages of the process of exhaustion, whilst yet there is a considerable amount of air in the fall-tube, the successive drops of mercury move separately down the tube, almost silently, being separated from one another by the intervening cushions of air, which, as they descend the tube, become more and more compressed. As a higher degree of rarefaction is attained there is no longer a sufficient cushion of air, the drops fall smartly through the vacuous space with a loud metallic clinking sound as they strike upon the top of the barometric column, which occupies the lower 30 inches or so of the fall-tube. At the bottom of the fall-tube the air and mercury enter a suitable vessel, K, from which, if desired, the air that has been carried down the fall-tube may be collected. The mercury which flows into K must be periodically collected and poured again into the supply funnel at the top. In the second form, figure 22, a downward bend is inserted between the supply funnel and the point where the mercury begins to break away into drops. This bend leads to a small chamber, virtually the pump-head, from the end of which the mercury falls in drops. The flow is regulated by a pinch-cock, which can be screwed up to nip, more or less tightly, a piece of flexible India-rubber tubing inserted in the supply tube. In this figure there is also shown a small mechanical air pump for rapidly producing

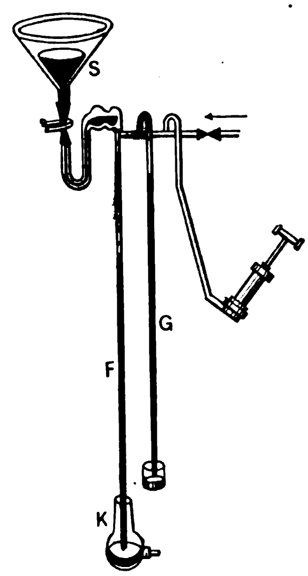


Fig. 22.

Sprengel's Pump. (Second Form.)

the first partial exhaustion, and barometric gauge, *b*, to show the degree of rarefaction attained.

The introduction of the Sprengel form of pump at once attracted a revived attention to the advantages of mercurial pumps for exhausting, and it was soon in the hands of many experimenters. Graham[1] applied it to extract minute quantities of gases in his researches on gaseous diffusion; Bunsen[2] adapted it for the purpose of hastening filtration, employing a form somewhat modified to admit of the use of drops of water instead of drops of mercury. Improvements began to be introduced in the details of construction, as experience revealed the imperfections. It was found that air was liable to be carried down into the pump through the supply vessel at such times as more mercury was poured in above; it was necessary to trap off such air bubbles to prevent them from vitiating the vacuum already attained. It was found necessary to introduce vessels containing drying materials, such as concentrated sulphuric acid, or glacial phosphoric acid. The fall tubes were found to have an awkward habit of cracking and breaking off just at a point 30 inches above the lower end, in consequence of the hammering action of the falling drops during the later stages of exhaustion. Better and more reliable gauges were required to verify the degree of rarefaction. Lastly, some remedy was wanted for the difficulty experienced in forcing down through the 30 inches of barometric column the last small traces of residual air in the fall tube. The falling drops hammered these residual bubbles into the mercurial column below them; the air bubbles, on their part, always tended to rise again into the upper part of the tube; often they would stick to the wall of the glass tube, refusing to move, though the mercury continued to flow past them. The remedy of turning on a more sudden flow of mercury to sweep them out was not always successful. Indeed, when it is remembered that these last residua must be recompressed to atmospheric pressure, in order to expel them at the bottom of the tube, it would seem strange if such a method of expelling the residual air should prove effectual. Some of the desired improvements were originated by Dr. Sprengel himself, others by instrument makers, who constructed Sprengel pumps for their customers.

An improved joint, made by grinding the conical end of a glass tube in a conical socket at the end of another tube, and placing mercury in the cup surrounding the junction, was described by Dr. Sprengel.

By the year 1874[3] two modifications had come into extensive use; the mercury, instead of running direct into the pump from the supply vessel was carried down a vertical tube, surrounded by a wider external one, so that any air bubbles accidentally carried down escaped up the wider tube instead of entering the pump; also after passing this trap, the mercury was forced up again in moderately wide tube, ascending to a slightly lower level than the supply vessel, and again descending. The upper bend of this tube communicated at its highest point with a small stoppered chamber, partially exhausted of air by filling it with mercury, which was then allowed to run out. As the mercury passed over this bend, it consequently fell through a partially exhausted space, and was still more thoroughly freed from air before ascending to the head of the actual pump. These improvements are embodied along with others in the form constructed by Alvergniat,[4] of Paris, who worked for and with the advice of M. H. Sainte-Clare Deville.

In most of the modern Sprengel pumps the mercury is introduced into the pump head by a jet tube with a narrow orifice, whence it spurts in a fine stream, and falls into the widened tube of the fall tube; in some other forms it merely breaks away in drops over a bend in a wider tube. This form is simpler to construct.

A very important addition was the improved gauge introduced by McLeod,[5] in which was applied the principle of compressing a known volume of the rarefied air or gas into a smaller known volume (the ratio of the two volumes being accurately known) and then measuring its pressure, and so calculating backwards. This method, suggested long before by Arago, and employed by Régnault[6] for the purpose of testing the perfection of the vacuum of a barometer, may be regarded as a refinement upon the method of the "pear gauge" invented by Smeaton. In Smeaton's invention the residual air left in the pear-shaped glass vessel, placed with its lower end in mercury, under the receiver of an air pump was, on the restoration of the external pressure, driven out of the body of the pear into its narrow upper end, where its volume could readily be measured. In McLeod's original gauge a globe of about 48 cubic centimeters was employed, opening at the top into a narrow volume tube seated at the top, and suitably graduated. This apparatus communicated below with the pump, and stood at the top of a barometric column which was provided at its foot with a flexible rubber tube and a supply vessel, by raising which (by an action like that of Geissler's pump) the mercury could flow up into the gauge, and force the residual air in the bulb into the volume tube at the top. A neighboring pressure tube rendered the increment of pressure (due to compression) evident at a glance, and all that remained to be done was to multiply this increment by the ratio between the volume now occupied by the residual air and volume it originally occupied. McLeod showed how to carry the calculation to a second approximation.

About the same time Crookes[7] introduced several improvements in detail:—A method of lowering the supply vessel to refill it with the mercury that had run through the pump; the use of taps made wholly of platinum to ensure tightness; the use of a spark gauge to test the perfection of the vacuum by observing the nature of an electric spark in it; the use of an air trap in the tube leading up to the pump head; the method of connecting the pump with the object to be exhausted, by means of a thin, flexible, spiral glass tube; the method of cleansing the fall tube by letting in a little strong sulphuric acid through a stoppered valve in the head of the pump. In carrying out these experiments, Crookes was assisted by Mr. Gimingham, whose further

1. Graham. "Journ. Chem. Soc.," xx., 247, 1866. See also "Pogg. Ann," cxxix., 563, 1866.

2. Bunsen. "Ann. Chem. Pharm.," cxlviii., 277, 1868. See also "Ann. Chem. Pharm.," clxv., 159; and "Phil. Mag.," xlv., 153, February, 1873. Compare also with water pump of M. W. Johnson, "Chem. Soc. Quart. Journal," 1852, p. 186.

3. See E. J. Osmond in "English Mechanic," xix., 372, 1874, giving drawing of Sprengel pump.

4. Alvergniat's form is depicted in Violle's "Cours de Physique" (1884), i., 947. The form commonly used in Germany is given in Weinhold's "Physikalische Demonstrationen" (1881), 171.

5. McLeod. See "Phil. Mag." (4) xlviii., 110, 1874, and "Proc. Phys. Soc. Lond.," i., 30, 1874.

6. Régnault. "Rélation des Expériences" (1847), i., 491.

7. Crookes. "Proc. Roy. Soc.," xxxi., 446, 1881; also "Proc. Phys. Soc., Lond., i., 35, 1874.

contributions to the development of the pump will presently be noticed. It was with this improved pattern of Sprengel that Crookes was able to carry out that remarkable series of researches upon the repulsion accompanying radiation, which culminated, in 1875, in the invention of the radiometer, and later led to the discovery of the phenomena of "radiant matter."

Professor R. A. Mees[1] described another modification, the fall tube being constructed with a series of bends constituting fluid

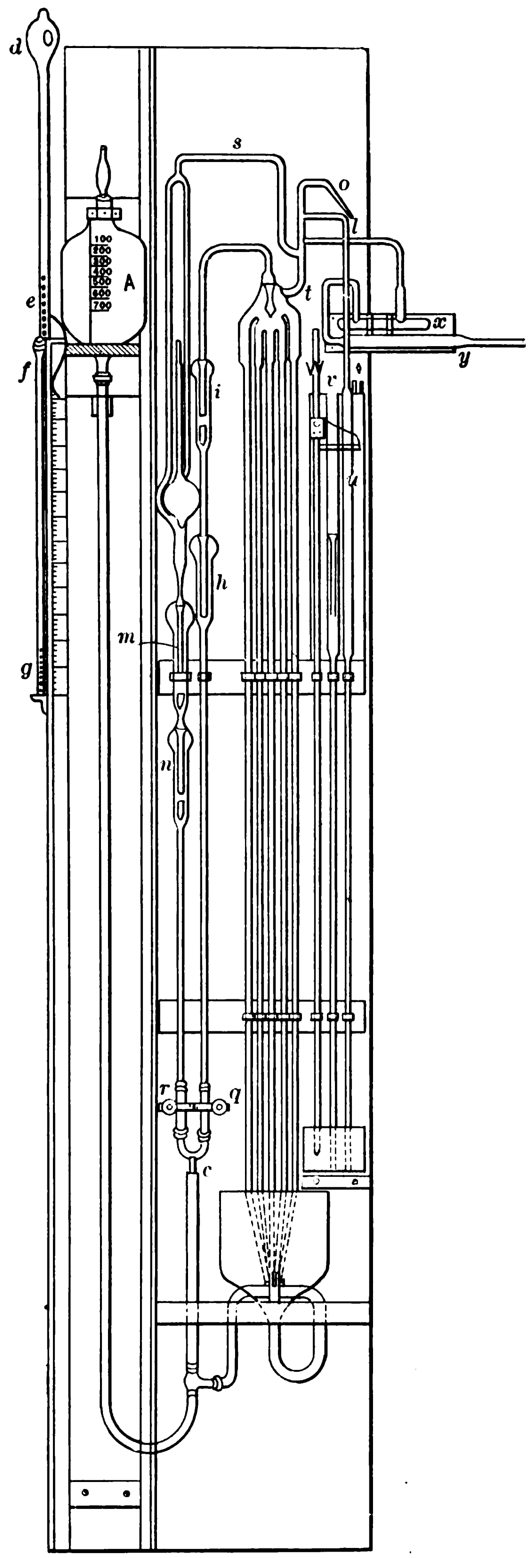


Fig. 23.

Gimingham's Pump.

valves or traps, in which the minute portions of air carried down the fall tube might accumulate in order to be swept out the more effectually when aggregated in larger bubbles. This pump also had a peculiar automatic stop cock.

From 1875 to 1884 a series of modifications were introduced by Mr. Gimingham.[2] Firstly, the process of exhaustion was accelerated by the employment of multiple fall tubes, receiving their streams from a distributing jet within the pump head. Three fall tubes were employed, then five, later seven; but five appears to be a preferable number. In figure 23, which embodies Gimingham's various improvements with the earlier ones of Crookes, there are five fall tubes shown. Careful experiments to determine the best size of bore for the fall tubes gave the following results when exhausting a vessel of 136 cubic centimeters capacity :—

Diameter of bore in millimeters.	Rate of flow in cubic centimeters per minute.	Total quantity of mercury in cubic centimeters requisite to reduce pressure to one millimeter of mercury.	Total time required. in minutes.
2.4	83.3	2,500	30
2.4	20	1,600	80
1.8	20	700	35
1.8	50	1,200	24
1.4	10	1,800	180
1.4	25	2,700	120
1.1	20	4,000	200

The enormous time required in the last case was due to incessant choking up of the upper part of the fall tube, owing to friction in the narrow bore. The conclusion derived from comparison of results with varying bores is that at high degrees of exhaustion the last portions of air or gas are carried out by entanglement with the mercury, and not by the mercury acting in definite "pistons" to sweep out the gas. With respect to the length of the fall tubes, it was found that those 39 inches (1 meter) long, giving a fall of 9 inches (or 22.5 centimeters), exhausted more rapidly than tubes only 33 inches (85 centimeters) long. Tubes longer than 39 inches were found liable to fracture, in consequence of the severe concussions of the mercury as it fell upon the top of the barometric column. Gimingham also described an improvement in the McLeod gauge, making its indications at once more sensitive and more reliable. Several minor improvements are also mentioned; an improved vacuum tap, an improved form of air trap, a radiometer gauge, and a bulb containing crumpled gold leaf, to absorb mercury vapor.

The lettering in figure 23, which is taken from Gimingham's paper in the "Journal of the Society of Chemical Industry," is as follows: The supply vessel, A, communicates by a long tube with a forked tube, C, leading to two regulating pinch cocks, *r* and *q*. The left-hand tube leads up through two air taps, *n* and *m*, to the McLeod gauge; the right-hand tube, through two air taps, *n* and *i*, to the pump head, where the mercury is thrown in jets into the tops of the five fall tubes. The tube, *t*, is the exhaust tube, which has three branches, one, *s*, leading to the McLeod gauge, one, *l*, leading to the barometric gauge, *u*, and one leading through the drying tube, *x*, and the absorbing tube, *y*, to vessel, lamp, or bulb, which is to be exhausted. A comparison barometer is placed at *v*, and a measuring rod to read off barometric heights is fixed at *w*. The arrangements at *d*, *e*, *f*, and *g*, relate to a mechanical method of counting the number of times that the supply vessel has been let down to be replenished.

Mr. Gimingham has also suggested[3] a mechanical mercurial pump with valves.

A five-fall Sprengel pump, of simpler construction, and jointed with India-rubber tube joints, is used by the Thomson-Houston company, in their factory at Lynn, Massachusetts. The Anglo-American (Brush) company have also used a modified five-fall tube in their works at Lambeth. Another multiple fall pump has been patented by Mr. Donkin.[4]

Dr. L. von Babo[5] described an ingenious method of making the Sprengel pump supply itself with mercury, by the device of connecting it to a water aspirator, worked by a constant stream of water. This aspirator drew in air and mercury at the lower part of the pump, and lifted it up through a narrow tube to a height above the level of the mercury in the supply vessel. Incidentally, this method has the advantage, apparently not noticed by von Babo, of enabling the full tube to be considerably shortened; it has the disadvantage of exposing the mercury to water vapor during a part of its circulation.

1. Mees. See "Catalogue of Loan Collection of Scientific Apparatus," 1876, p. 131.

2. Gimingham. "On a new form of the Sprengel Air Pump." "Proc. Roy. Soc.," clxxvi., 396, 1876; and "Contributions to Development of Sprengel Air Pump." "Journ. Soc. Chem. Indust.,"

3. Gimingham. See "English Mechanic," xxxvi.," 442, 1882.

4. Donkin. Centralblatt für Optik und Mechanik, vii., 216, 1886.

5. Von Babo. "Berichten d. naturforsch Gesellsch zu Freiburg," ii., Heft. 3, 1879.

Macaluso[1] proposed the addition of a Mariotte's flask, to regulate the flow of mercury, thereby avoiding the need of having a movable reservoir.

Rood,[2] in 1880, described several details of some novelty; an iron valve in the bottom of the supply vessel, capable of fine regulation by a screw, served to determine the rate of flow of the

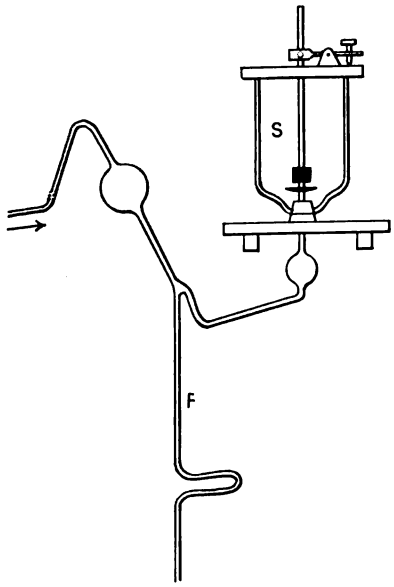


Fig. 24.

Rood's Pump.

mercury. Immediately below the supply vessel, the mercury entered a vacuum bulb (see figure 24), designed to free the mercury from air and moisture, the mercury dropping at once to its lower part, which should be level with the point where the curved supply tube joins the fall tube. This bent tube, about 20

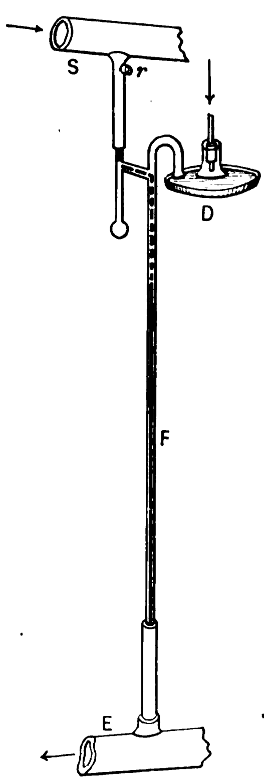


Fig. 25.

Edison Pump (1885).

centimeters long, after descending gently, ascends about 4.5 centimeters; it is made of about the same diameter in the fall tube. The fall tube, as in Mees's pump, is provided with bends. Rood also described a modification of the McLeod gauge. His pump was so mounted that all parts of it could be heated by means of a Bunsen burner. Great importance was attached by this experimenter to this point; as it appeared that much higher exhaustion was thereby attained.

In 1882, Hannay[3] proposed to replace the mercury by a fusible alloy of lead, bismuth, and tin, melting at 94°; by this means it was thought that the necessary imperfections arising from the pressure of mercury vapor would be avoided.

The Sprengel pump employed by the Edison company (New York, 1885) in the manufacture of glow lamps, has a simple fall tube cemented (as shown in figure 25) at its lower end into an iron tube, E, which carries away the ejected air and mercury from a series of such pumps. An iron supply pipe overhead feeds the pumps. Strong sulphuric acid placed in a shallow-glass vessel, D, is used for drying.

CLASS IIa.—SHORTENED DOWNWARD-DRIVING PUMPS.

Stearn,[4] in 1887, working in conjunction with Swan at the problem of perfecting the incandescent lamp, devised a shortened Sprengel pump. It is obvious that the column of mercury in the

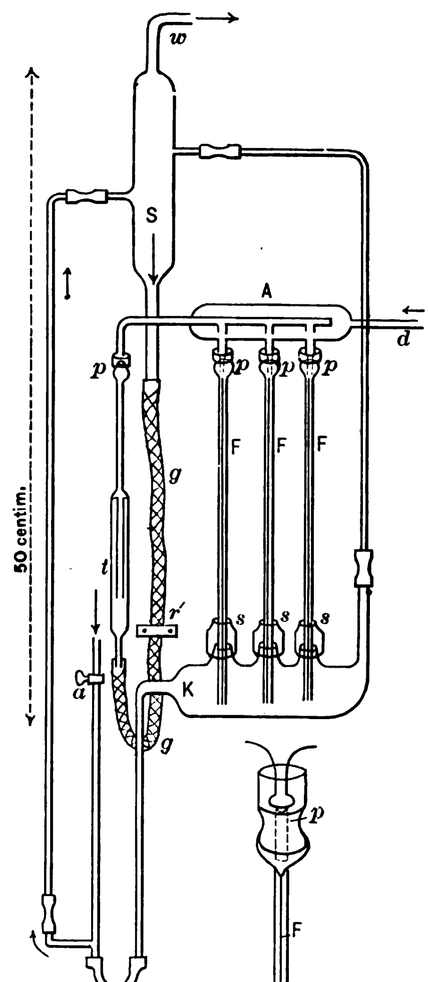


Fig. 26.

Nicol's Pump.

Sprengel fall-tube stands, during the later stages of exhaustion, at about 76 centimeters height, simply because the difference of pressure between the space inside the tube and outside it is about equal to one atmosphere. By removing a portion of the external pressure, the fall-tube may be shortened to any desired extent. Accordingly Stearn applied an auxiliary pump, not at the top as Sprengel had done, to accelerate the early stages of exhaustion, but at the bottom; the collecting chamber, K, being for this purpose closed, and put into communication with the auxiliary pump. Stearn's pump has undergone various modifications; in a recent form[5] there are three fall-tubes of only about 10 inches length, completely enclosed in a partially exhausted chamber. In this pump there are also means provided for carrying up the mercury

1. Macaluso. See "Wied. Beibl.," iv., 516, 1880.

2. O. N. Rood. "Sillim. Journ.," xx., 57, 1880; *i. b.* xxii., 90 1881. See also *New York Times*, November 19, 1880.

3. Hannay. "Philos. Magaz." [5] xiii., 229, 1882.

4. Stearn and Swan. "On a new form of Sprengel's Air-pump." Rep. British Association, 1877, p. 43.

5. See Gordon's "Practical Treatise on Electric Lighting, 1884, p. 65, giving an excellent picture.

from the collecting vessel back to an upper supply-vessel by closing certain taps and opening others which admit the atmospheric air. By this means an extremely small quantity of mercury is made to do duty again and again; and the exhaustion is rapid, because with such short fall-tubes there is less liability of the air-bubbles to stick in the fall-tubes. The action of the pump is made automatic by giving a periodic motion to a three-way cock, which puts a lower receiving chamber alternately in connection with the atmosphere and with the partial vacuum of the

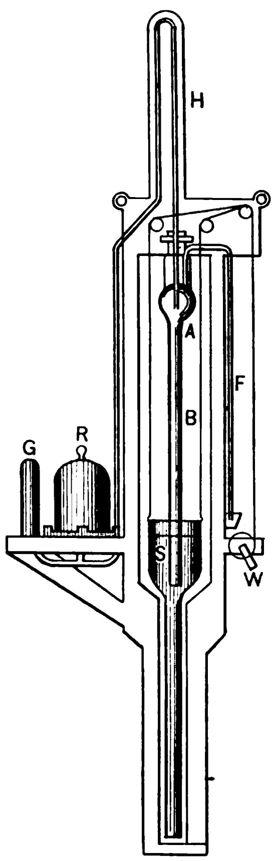


Fig. 27.

Mile's Pump.

auxiliary pump. Stearn has embodied sundry other modifications in patent specifications.[1]

A compact modification of Stearn's pump has been devised by Mr. Swinburne,[2] who has also tried an inverted Sprengel pump.

The most recent shortened Sprengel pump is that of Dr. W. W. J. Nicol, described before the British Association at Manchester in 1887. Its arrangements are depicted in figure 26. The principle of its automatic action is identical with that of Von Babo, an auxiliary water dropping air-aspirator (not shown in the figure) being employed to draw in air at the aperture A, regulated by a tap. This air draws up the fallen mercury in drops, through the return tube, Z, on the left, and returns it into the supply chamber, S, at the top, whence it passes downward through a rubber tube, squeezed between the jaws of a regulating pinch-cock, X, and rises through an air-trap, *t*, into the pump-head. The distributor is simply a horizontal glass tube, sealed into the pump-head, and pierced with small holes above the openings of each fall-tube. (This form of distributor originated independently with Mr. J. T. Bottomley and with Mr. Proctor.) The fall-tubes, F, F, F, are connected to the pump-head in the following manner. Below the pump-head are sealed, on short pieces of glass, tubing of at least five millimeters bore. These are provided with small flanges, and drawn out conical below, so that they can be pushed very tightly through small India-rubber plugs, *p*, *p*, *p*, which are firmly fixed in mercury cups. These mercury cups, which are strangulated, so as to nip the rubber plugs, are sealed to the fall-tubes. The lower ends of the fall-tubes pass into the collecting vessel, K, through simple packings, *s*, *s*, *s*, of rubber tube. The arrows show the course of the mercury. The tube, *d*, leads to the drying apparatus, and to the vessel to be exhausted. This pump can, of course, be used for exhausting only, not for collecting the gas for analysis. The entire height of the apparatus is less than one meter. A very small quantity of mercury—only 800 cubic centimeters—is required. The entrance of water-vapor at S or *a* is prevented by the use of tubes containing calcium chloride. These pumps are now manufactured for sale by F. Müller, successor to Dr. Geissler, of Bonn.

CLASS III.—UPWARD AND DOWNWARD-DRIVING PUMPS.

The earliest example of a pump which drives the air up one barometric column and down another, is the remarkable pump devised by Professor J. Mile,[3] of Warsaw, in 1828. This pump is described by its inventor as a hydrostatic air-pump without cylinders, taps, lids, or stoppers. The description, as will be seen by figure 27, is literally true. The mercury is raised in the barometric tube B, and pump-head, A, by lifting an external cistern, S, of mercury by means of a winch, W. The rising of the mercury first cuts off communication with the vessel to be exhausted by entering the mouth of the exhaust-tube, which is sealed in through the pump-head; and on further rising it expels the enclosed air through a narrow tube, F, sealed in at the top, which bends over to the right and terminates below in a cup of mercury into which its open end dips. This exit-tube and cup constitute a barometric trap, for when the supply cistern is lowered the air cannot return, the mercury rising in the tube, F, to a height depending upon the degree of internal rarefaction. To prevent the mercury from being forced into the vessel that is to be exhausted, the exhaust tube is prolonged overhead to a height exceeding that of a barometric column. The total height of this pump is, therefore, necessarily, about nine feet. It may be looked upon as a sort of Swedenborg pump, the two valves that opened inwardly and outwardly into the pump-head being replaced by barometric air-traps. With such a pump, properly used, a fairly high degree of exhaustion ought to be possible. Strange to say, this pump appears to have fallen into utter oblivion, and its useful features have been several times re-invented.[4]

The use of a second barometric column, down which the air is expelled from the pump-head, is generally attributed to Professor

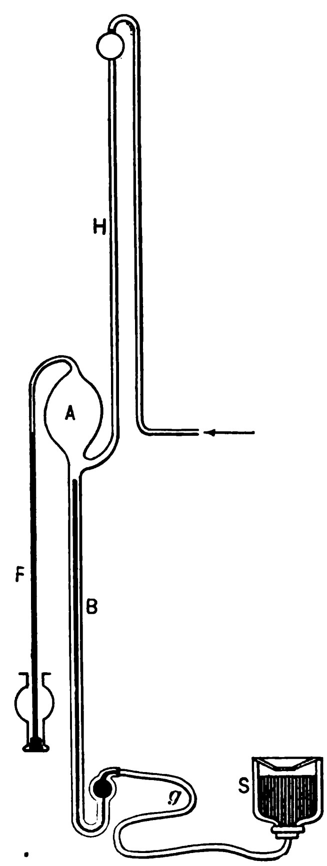


Fig. 28.

Toepler's Pump.

Toepler,[5] of Dresden, whose form of pump is shown in figure 28. Save in the use of a flexible rubber-tube, and in the manner of bringing the exhaust tube to the lower side of the pump-head,

1. Stearn. Specification of patent, 5,000, of 1881. See also Dredge's "Electric Illumination," ii., p. 364. Stearn's shortened Sprengel pumps have been now for several years furnished to the public by Messrs. Mawson & Swan, of Newcastle-on-Tyne.

2. Swinburne, *Electrician*, xix., 72, 1887.

3. Mile. Neue hydrostatische Luftpumpe ohne Kolben, Haehne, Kappen, und Stöpsel. "Dingler's Polytechnisches Journal," xxx., 1, 1828.

4. See, for example, H. Sutton, in *English Mechanic*, xxxi., 1882, as well as Toepler and Mendeleeff.

5. Toepler. Ueber eine einfache Barometer-Luftpumpe ohne Hähne, Ventile, und Schädlichen Raum. "Dingler's Polytechnisches Journal," clxiii., p. 426, 1862.

this is identical with Mile's pump. A pump of similar form is sometimes attributed to Mendeleeff; but the writer has been unable to verify the reference. This pump has many of the advantages and disadvantages of the Geissler form of pump. It requires either the tall overhead tube or else an automatic valve. The exit tube, F, is more liable to fracture than any part of the Geissler pump. But, as there are no taps to get out of order, a higher degree of exhaustion can be attained than with any three-way tap arrangement opening into the outer air. There is no need even for any other gauge than the pump itself; for, as Toepler[1] has shown, the degree of exhaustion can be measured (as in the McLeod gauge) by raising the mercury in the pump-head to a marked point on the narrow tube just above the pump-head, so as to compress the residual air into the top of the narrow exit-tube, and then reading off the volume and the pressure of the same, and making the required calculations. It possesses this obvious advantage, that the last residue of air in the pump-head are swept down the tube F, by the mercury that falls over the bend—"Sprengelized" over, one might almost say. In fact, if it were not the case that this pump antedates both Geissler's and Sprengels', one would be disposed to regard it as a combination of the Geissler and Sprengel pumps.

(To be continued.)

1. Toepler. "Sitzungsber. d. Naturwiss. Gesellsch. Isis in Dresden," 1877, p. 185. See also Bessel-Hagen, "Wied. Ann.," xii., 484, 1881.

ABSTRACTS AND EXTRACTS.

ELECTROLYSIS OF IRON SALTS.

BY ALEXANDER WATT.

(Continued from page 66.)

Ammonio-Citrate of Iron.—A solution of this salt was prepared by first dissolving recently precipitated carbonate of iron in a strong and hot solution of citric acid; the solution was then allowed to cool, when liquid ammonia was added, and the solution was then ready for use. With the current from five small cells a copper plate received a bright silvery deposit of iron immediately after immersion, and maintained this character for some time; but, owing to the anode not becoming freely dissolved, the solution eventually yielded its metal very slowly.

Ferrate of Potassa.—A deposit of iron may be obtained from a solution of this salt, by using a moderate current, but the liquid soon decomposes with the formation of peroxide of iron.

Sulphate of Iron and Sulphate of Magnesia.—For obtaining electrotypes of iron, MM. Jacobi and Klein first deposit a film of copper upon lead or gutta moulds in the usual way, and after well rinsing they are at once placed in a bath composed of sulphate of iron 139 parts, sulphate of magnesia 123 parts. These are dissolved together in hot water, and a little oxalic acid, as also some iron shavings added. The solution is kept in a well-stoppered bottle or carboy, in its concentrated state, and when required for use is diluted with water until its solution has a specific gravity of 1.155 (water being 1,000). In working this solution oxide of iron forms on the surface of the liquor, which must be skimmed off with some of the solution and shaken up in a bottle with a little carbonate of magnesia, and after settling the clear liquor is returned to the bath. The iron deposited from this bath is very hard and brittle, therefore the electro deposit must be carefully handled when separating it from the mould. The copper is removed from the surface of the electrotype, either mechanically, or by dipping it in strong nitric acid.

Ferrocyanide of Iron.—The following solution, devised by Boettger, for coating engraved plates, is probably the only cyanide preparation of any practical value:—Ferrocyanide of potassium 10 grammes, Rochelle salt 20 grammes, are dissolved in 100 cubic centimeters of distilled water. To this is added a solution composed of persulphate of iron 8 grammes, dissolved in 50 cubic centimeters of water. A solution of caustic soda is next added, drop by drop, with constant stirring, until a perfectly clear liquid is obtained of a light yellowish color. This solution, which would have little action upon an iron anode, would require to be constantly strengthened by the addition of concentrated liquor.

Protonitrate of Iron.—A solution of this salt yielded a black deposit of iron in a state of fine division, interspersed with glistening particles of the metal palpable to the touch. A quantity of nitrate of potash was next added to the solution, when at first there was a slight disposition for the metal to go down in the reguline form, but after a few seconds' immersion the plate again blackened, and in less than a minute it became thickly coated with a gelatinous film, covered with hydrogen bubbles of about the size of mustard seed, which remained on the plate for at least half an hour, being coated with a thin rusty film. On leaving a fresh plate in the solution for about an hour, nearly the whole of the iron was thrown down in the form of a black or greenish-black gelatinous mass, which oxidized with great rapidity. A solution of the protonitrate was next made by the battery method, by passing a current from five small Daniell cells through a sheet-iron anode, suspended in a very dilute solution of nitric acid, the circuit being completed by a carbon cathode. The liquid being a good conductor, the electrolytic action was very energetic, and the iron anode became rapidly dissolved, and in less than half-an-hour metallic iron, in the form of granules, was deposited upon the carbon. A copper plate was now substituted for the carbon, which at first received a dark gray metallic film, but in the course of a few moments the deposit assumed the form of a black gelatinous mass, which subsequently oxidized, forming a bright orange-yellow powder.

Double Sulphate of Iron and Potash.—A bath was prepared from a mixed solution of the respective salts, the iron salt being in excess. With three cells of the small Daniell battery, arranged in series, a fine white and very bright deposit was obtained upon a copper plate immediately after immersion, and the deposition proceeded very uniformly for half-an-hour, when the deposit became somewhat streaky; this was remedied, however, by adding more sulphate of potash. Deposition took place very freely, and the anode was considerably dissolved in the course of an hour. This is undoubtedly a very good electrolyte for the deposition of iron, and does not appear, if faintly acid, to oxidize so freely as the ammonio-sulphate solution.

Further Experiments with Persalts of Iron.—In my first paper I gave the results of some experiments with solutions of perchloride and persulphate of iron, in which I was unsuccessful in obtaning deposits of metallic iron. Having recently electrolyzed some other persalts of this metal with somewhat more favorable results, I determined to renew my experiments with the perchloride and persulphate with a view to ascertain if it would be *possible*, under other conditions than those which governed my former trials, to deposit metallic iron from solutions of these salts. In treating the pernitrate as explained in the last paper I succeeded in obtaining copious deposits of metallic iron in a highly comminuted condition, thereby proving that the electro deposition of iron from a persalt (albeit not in a reguline form) is possible. Gore, in his "Art of Electro-Metallurgy," page 245, states that "solutions of persalts of iron yield no metallic deposit, but are reduced to protosalts by the passage of an electric current." That this statement is not correct I will now endeavor to prove. In the first place, a moderately strong solution of pernitrate of iron yields freely a black deposit of metallic iron, which may be collected, as I have shown, and possibly employed in pharmacy. Further, I obtained a reguline metallic coating of iron upon a strip of sheet copper from a solution of the peroxalate of iron. This latter result led me to believe that if the proper condition of the electrolyte could be obtained it was probable that solutions of all persalts of iron would yield metallic deposits. To determine this I prepared a sample of perfectly pure hydrate of the sesquioxide of iron, which was carefully washed and employed in a moist state. With this I formed saturated solutions of perchloride and persulphate respectively. I then determined to try if I could obtain a metallic film upon a copper cathode from a very weak solution of the perchloride (1 drachm of concentrated solution to 3oz. of water) with the current from five small Daniell cells in series, and was pleased to find that under these conditions a film of metallic iron began to form immediately, and in a few moments the plate was covered with a fairly bright deposit of the metal; after awhile, however, the film became blackish at the lower corners. A solution of the persulphate of iron in about the same proportions was next tried with three cells, when a bright deposit of iron at once took place at the corners and lower edges of the plate, which gradually extended upwards in the form of a horseshoe, which character it maintained until the plate was withdrawn. I have frequently noticed that some weak solutions of iron—especially *very* dilute solutions—yield deposits of this form, the metal positively refusing to coat the upper portion of the immersed surface; on the other hand, instances frequently occur, not with iron alone, but with some other metallic solutions, in which the film, while absolutely refusing to form upon the lower surface of the cathode, appeared only on the surface nearest the top of the liquid. Being thus far successful with the perchloride and persulphate solutions, I next tried a very weak solution of the pernitrate. In this trial I was less successful, but when the cathode was briskly agitated in the bath a greenish, non-adherent film was obtained, which, when dried and removed from the plate, was attracted by the magnet. It was metallic iron, therefore, but only in a semi-metallic state until dried. Having thus proved that iron *can* be deposited from solutions of its persalts when the proper conditions have been arrived at, I will now proceed to describe some futher experiments which have recently engaged my attention.

Peroxalate of Iron.—A solution of this salt was prepared by dissolving freshly precipitated hydrated sesquioxide of iron in a hot and strong solution of oxalic acid. The hydrate entered into solution very freely, forming a greenish-yellow liquid. The current from five small Daniells was used, with an iron anode and copper receiving plate as before. Shortly after immersion the cathode became coated with a metallic film of a gray color.

After a few minutes' immersion a gray non-metallic pulverulent deposit rested upon the plate, which was easily brushed off, while a similar powdery film, but of a yellow color, appeared on the immersed portion of the anode. In a short time the liquid became turbid, and a yellowish deposit was subsequently found at the bottom of the vessel.

Sesquicitrate of Iron.—A bath was prepared from this salt by digesting freshly precipitated and moist hydrated sesquioxide of iron in a hot and nearly saturated solution of citric acid; when cold the solution was diluted with about twice its bulk of water. Five Daniells were employed, when a strip of sheet copper received a deposit of iron soon after immersion. The film, however, was neither so bright nor of so good a color as that obtained from the protosalt.

Sesquiacetate of Iron and Acetate of Soda.—A solution of the sesquiacetate was first formed by dissolving hydrated peroxide of iron in acetic acid with the aid of moderate heat. The solution was next moderately diluted (with about two parts of water), and acetate of soda crystals then added and dissolved in the liquid. With the current from five Daniells, a metallic deposit of iron was at once obtained upon a copper plate, this electrode being allowed to remain stationary in the fluid. In about a quarter of an hour the film—which retained its metallic character—assumed a grayish color, and became blistered all over, showing that the deposit, though reguline, was non-adherent.

Benzoate of Sesquioxide of Iron.—A solution was prepared by dissolving freshly precipitated hydrate of peroxide of iron in a hot solution of benzoic acid; this acid, being very sparingly soluble, even in hot water, yielded but a very weak solution, so it was resolved to use it while still warm. The solution was a very bad conductor, and no deposit could be obtained with five Daniells, while the cathode was stationary. When this electrode was briskly agitated in the solution a slight metallic film appeared, on the upper part of the plate only. There was a moderate evolution of gas.

Benzoate of Protoxide of Iron.—A solution was formed by dissolving recently prepared carbonate of iron in a hot solution of benzoic acid. As in the previous case the solution was a poor conductor, and yielded its metal only when the cathode—a strip of sheet copper—was briskly moved about in the bath. The same number of cells were used as in the former experiment, and the solution employed hot, but only a trifling film of iron appeared upon the upper portion of the receiving plate.

Ammonio Nitrate of Iron.—This bath was prepared by dissolving iron in cold dilute nitric acid by the action of the current, the operation being kept up until the solution was as neutral as possible, when a little ammonia was added. As is the case with most other nitrates, the solution had little disposition to yield a reguline deposit of metal. A slight metallic film appeared upon the cathode for an instant, but this quickly changed into a black deposit of pulverulent iron precisely similar in character to that obtained from the persalt. This black film, which soon became very thick upon the plate, was slimy to the touch, and consisted of metallic iron in a highly comminuted state, interspersed with bubbles of hydrogen, some of which were of considerable size, and retained their position upon the plate for many seconds—probably half a minute. The black deposit was washed off the plate into a glass containing hot water, and a fresh plate immersed in the liquid, and allowed to remain stationary for about two minutes, by which time it received a copious deposit of the same character as before, which was afterwards removed by washing, as in the previous case. Several plates were coated with the black deposit in this way, and the finely-divided metal afterwards well washed, drained upon a filter, and dried. The black powder thus obtained was then placed upon a sheet of paper, and treated with the magnet in the following way:—A piece of thin paper was laid over the poles of a small horseshoe magnet—to prevent the finely-divided metal from attaching to the magnet itself—which was then drawn across the metallic particles, but at a short distance from them, when they rapidly ascended and clung to the paper, and to each other, forming a metallic fringe of about a quarter of an inch in depth and about an inch in length. The fine metal, thus suspended, was then conveyed to a second piece of paper, and the magnet withdrawn, when, of course, the metallic particles became dislodged and fell upon the paper. The remaining atoms of metal were collected and transferred in the same way, when it was found that the first piece of paper, upon which the fine metal had been placed was perfectly free from particles of any kind, showing that the black deposit obtained from the solution in question consisted solely of metallic iron. It should be mentioned that when these black deposits of iron, after being drained from surrounding water, are dried slowly, a film of oxide forms upon the surface of the particles, giving the dried material a reddish tint. This does not, however, prevent the magnet from attracting them. In this experiment the anode, which was much worn, remained exceedingly bright.—*The Electrician* (London).

(To be continued.)

THE SOCIETY OF TELEGRAPH ENGINEERS AND ELECTRICIANS DISCUSS THE ALTERNATING SYSTEM.

At a recent meeting of the Society of Telegraph Engineers and Electricians two papers were read dealing with the subject of alternating current converters or transformers and the distribution of electricity by means of these appliances. The first of these papers, by Mr. Kapp, we reproduce in our present issue. The second was by Mr. J. Kenneth D. Mackenzie, and in it the question of distribution was treated from a general point of view, including dynamos, mains, transformers, and other matters which may best be described as coming under the title of general principles and administration of electric light stations. These two papers are the first on the subject which have been submitted to a scientific society in England. Information in connection with transformers has been carefully withheld by the makers and users of such apparatus—a state of things probably due to the pending litigation on transformers. The paper of Mr. Mackenzie was specially interesting, as this gentleman has had much practical experience in the working of converters or transformers. The author distinguished between polar and non-polar transformers, the first being of the type of the original Rumkorff induction coil, whilst the latter are developments of the well-known Faraday ring. Messrs. Gaulard & Gibbs were the first to take up the subject on a commercial scale, employing polar transformers which had either a movable core or a fixed core provided with a movable gun metal shield, by which means the E. M. F. and the secondary circuit could be adjusted; but these devices were only adopted in their first experimental installations, when it was thought desirable to have means for readily adapting each transformer for the work it had to do. For permanent installations, however, where the conditions of supply could be settled beforehand, Messrs. Gaulard & Gibbs adopted the non-polar type of transformer, and introduced a series of improvements, the object of which was (1) reduction of electrical resistance, (2) maximum induction with a minimum weight of materials, (3) perfect symmetry between the primary and secondary circuits, and (4) an equal weight of copper in the two circuits. Referring to the manner of coupling up the transformers in a general system of supply, Mr. Mackenzie stated that transformers might be worked in various ways. If in series, the lamps fed from each transformer must also be placed in series, and two years ago he had jointly with Mr. Bernstein, made some experiments, which, so far as regulation went, were perfectly successful. The primary current was adjusted to the same strength for each experiment, and those lamps which were not required were simply short-circuited. He found it possible to short circuit the whole of the secondary without perceptibly increasing the current, and without any danger of overheating. The difficulty he found was not in the transformers, but in the dynamo. He found it almost impossible to maintain the current of the dynamo constant under varying loads, and considered improvements in this direction very desirable. Transformers might be worked in simple parallel arrangement, as is now customary, or they might be worked on the three-wire system, or on the parallel network system, both the primary and secondary mains being all joined in two networks. This is the system employed by Mr. Westinghouse in America. As regards the mains, Mr. Mackenzie is in favor of overhead wires, these being more easily insulated; but he recommends that they should be suspended from bearers, consisting of copper or phosphor bronze cables, by insulated hangers at about every yard. In certain localities the bearers might be steel cables; but in large towns copper or phosphor bronze would be preferable, as not so liable to destruction from atmospheric influences. The bearers should be designed so as to have at least a ten-fold margin of safety against breakage. One of the difficulties he found in connection with bearers was, that on long circuits they became charged with an alternating potential by induction from the mains, and a considerable shock would be felt by touching any of the bearers, although they were insulated from the main. In the early days of the Grosvenor Gallery installation, some difficulty was experienced from the mains by their inductive effect on the telephone wires, and owing to the number of complaints received from telephone subscribers, the company instructed him, in conjunction with Dr. Hopkinson, to investigate the subject, and report on the best method to remedy the evil. The installation was then worked on the series system, and the evil was removed by the simple device of running the return main parallel to the outgoing main over the whole district. By this means the effect of the current on the telephone wires in one main was neutralized by that in the other main. When the cables are placed underground the author suggests the employment of an earthenware channel, with a cover made as nearly as possible watertight. Within the channel are placed shelves of paraffined wood, on which the conductors rest, and at stated intervals drainage holes are provided for getting rid of water which might find its way into the channel. He does not advocate the use of lead covered cables. In the installation at Aschersleben

these cables were used both for the supply and the distributing mains; but it was found that the lead was destroyed by sparks due to a static charge, the cable forming a condenser, and these cables were ultimately abandoned. At the installation in Tours some difficulty was also experienced with underground cables; but since these were laid in earthenware troughs, similar in construction to those suggested by the author, no further difficulties were met with. The author also showed a plan of Port of Spain, in Trinidad, for which he had designed an electric light installation, there being about 20 miles of circuit.

In dynamos for alternating currents considerable improvements have been made during the last few years, the most remarkable of these being the adoption of iron in the core of the armature. In certain cases Mr. Mackenzie recommends the employment of a low tension dynamo at the generating station, and transforming the current from it by a large transformer into one of high tension, which is sent into the supply mains; but he is opposed to the system of employing dynamos of excessively large dimensions. In this connection he adversely criticised the proposal of one London electric light company to erect dynamos having armatures 42 feet in diameter, and requiring 5000 i. h. p., supplied by quadruple expansion marine type condensing engines. He thinks it far safer to employ a number of dynamos coupled in parallel, the capacity of each dynamo not to exceed about 10 per cent. of the total capacity of the station. There is no difficulty in working alternate current dynamos in parallel, and he has, in fact, done so with Siemens' machines at the Grosvenor Gallery; but he found that the synchronism between the machines was not very stable, and easily disturbed by external influences. With modern machines this difficulty might not prove so great. A diagram of the Kingdon dynamo was exhibited. The peculiarity of this machine is that both the field magnets and the armature form part of the same structure, and that the movable portion of the machine contains iron only, but no wire. Briefly described, the machine which the author and Mr. Kingdon are now building, and which is to absorb 50 h. p., consists of a circular yoke ring, 10 feet in diameter, having a number of short radial magnet cores projecting inwards. Between these revolves the armature wheel, which might conveniently also form at the same time the fly wheel of the engine. Every alternate core is wound with exciting wire, so as to produce north and south poles alternately on the inner end, whilst over the intermediate cores are placed the coils in which the alternating currents are generated. The revolving part consists of a wheel carrying on its outer circumference a number of soft iron armatures, the width of each being such as to span over the inner ends of two adjacent magnet cores. When the wheel is revolved, these armatures seem to carry north and south lines alternately, through the cores on which the armature wire is wound, and by this means alternating currents are generated.

Regarding the placing of transformers, Mr. Mackenzie is of opinion that the provision of a small transformer for each house is only admissible when the number of consumers is small; but for a general supply and for permanent work the transformer should be kept out of the house, and a sufficient number should be installed throughout the district, so that the maximum distance of any lamp from the nearest transformer should not exceed 120 yards Great care is to be taken in the wiring of houses, and he deprecated the system of utilizing the existing gas fitting for the attachment of lamps. In his own experience, when connected with the Grosvenor Gallery installation, and it was worked on the series system, he has known as many as eight houses plunged into darkness owing to short circuits occurring between the gas fittings and the electric wires in the first and last of these houses. If for reasons of economy it is necessary to use gas brackets, he recommends that their connection with the gas pipes should be interrupted.

The discussion on the papers read by Mr. Gisbert Kapp and by Mr. J. Kenneth D. Mackenzie was opened by Professor Ayrton, who agreed with Mr. Mackenzie that considerable credit was due to Messrs. Gaulard & Gibbs for drawing attention to, and practically working out, the method of distributing electricity by secondary generators. One reason why the importance of this system was not at first recognized was, perhaps, to be found in the fact that the measurements of the efficiency of the earlier apparatus were made in a crude and inaccurate way. Thus the potential difference at the terminals of the transformer was measured by a high-resistance dynamometer, and the current was measured by a similar instrument with a low-resistance, the product of these readings being considered as giving the energy expended in watts. Both authors seemed to consider it impossible to work the primary coils of the transformers in series when there was a varying resistance in the secondary, but by a method analogous to compounding a dynamo, he thought that this difficulty could be overcome. This idea of compounding had occurred to his colleague and himself some time ago, and they had attempted to solve the problem mathematically, but as the analysis became very complex they gave it up, and were proceeding to treat it practically when the same idea was patented by Zipernowski, and they had not therefore proceeded further with the subject. He was very glad that the idea of magnetic lag as distinguished from that due to Foucault currents, was gaining credence, as Professor Perry and himself had drawn attention to it years ago and been laughed at for their pains. But now, thanks to the experiments carried out by Professor Ewing, its existence was universally admitted. He had said something about wrong methods of measuring the efficiency of transformers, he would now point out correct methods of measurement. There was only one way of measuring the power given to a circuit in which self-induction took place, and this, which depended on the use of a quadrant electrometer, had been devised simultaneously and independently by Professor Fitzgerald and himself, and might be described as follows: Let P and Q be the terminals of an inductive resistance through which an alternating current is being passed by a dynamo. Let a non-inductive resistance Q S be put in series with P Q. Connect the quadrants of the electrometer to S, the other two to Q, and the needle of the electrometer to P, and observe the steady deflection. Secondly, disconnect the needle from P and join it to Q, and take a fresh reading. The difference between the readings thus obtained is a measure of the power expended in the circuit in watts. This method of measurement was theoretically perfect, but it depended for its truth on the assumption that the law of the electrometer, as given by Clerk-Maxwell, was the correct one. But with most electrometers in actual use he had found that this law was not satisfied, and he should present a paper on the subject on a future occasion. It has consequently been necessary to determine the efficiency in some other way, and in their experiments they had adopted the plan of measuring by a calorimeter the heat developed in the transformer, and had obtained in this way very fair results. On comparing the results thus obtained with those given by adopting the same method as Messrs. Gaulard & Gibbs had done in their earlier experiments, they found that figures given by the latter plan were in certain cases three times too great. Mr. Kapp had described two methods of rendering transformers safe, but a simpler plan than either was to connect one terminal of the secondary core to earth, which would not only prevent this coil acquiring a dangerous potential, but would also prevent workmen or others getting a shock from the electrostatic capacity of the coil, which would not be the case with the other methods mentioned by Mr. Kapp.

Captain Cardew remarked that the chief theoretical novelty in Mr. Kapp's paper was the method of calculating the power lost by heating; but he did not completely agree with Mr. Kapp's reasoning, which depended on the hypothesis of a molecular friction. This did not, however, appear to him completely satisfactory, as he was inclined to look on a molecule under cyclic magnetic changes as in the condition of a spring, in which, although the power given out might not be altered, yet lagging might occur. With reference to the danger of alternating current installations, this must always be very great when a potential of upwards of 2,000 volts was employed, as with faulty insulation all the conditions were favorable to a breakdown. He had waited a long time for the appearance of some method of reducing the risk, and had finally invented what he might call an electric trap himself, which had been described in Mr. Kapp's paper.

The foil mentioned by Mr. Kapp, was, however, of aluminium, and not of platinum, the lightest and not the heaviest of metals. The plan of putting one terminal of the secondary to earth as advocated by Professor Ayrton, increased the risk of a breakdown, as the strain on the insulation, which must be always more or less imperfect, was greatly intensified. With regard to Mr. Kent's device, he could only say that as a customer, or as a dynamo manufacturer, he should be perfectly satisfied with it, but as a supplier of electricity, he would prefer to adopt something else.

Mr. Bernstein said that in a large installation on the alternate current system the question of insulation became very serious, and it would therefore be advantageous, other things being equal, to work the transformers in series, as the average difference of potential was on this plan reduced to one-half of that obtaining with the parallel system of distribution. Moreover, the potential difference between the terminals of the primary coil of the transformer would also be reduced to perhaps one-fortieth of its value on the other system, and as the insulation of a transformer cannot be made very heavy without sacrificing the efficiency of the apparatus, this reduction of the potential difference greatly diminished the risk of a breakdown. With regard to Mr. Kent's safety device he thought it would work well, but there was such a thing as leading a current into temptation, that was to say, that if a current was given a chance to go to the ground it would not hesitate to take advantage of it. Professor Ayrton had mentioned the plan of connecting a terminal of the secondary to earth, and he would remark that when he had first brought out the contact-plug used in his system of incandescent lighting, Professor Forbes had pointed out that the same device could be used to connect the secondary coil of a transformer to earth, and would render it absolutely safe. The contact-plug consisted of a mixture of mercuric oxide and carbon, which had normally a very high resistance; if, however, through any considerable rise of potential a large current was forced through the plug, the

oxide was instantaneously reduced to metallic mercury, and the resistance practically eliminated. These plugs had been in operation in installations of incandescent lighting on the series system of distribution for over a year, and in that space of time had never failed to act.

After some remarks from Mr. Atkinson, Professor Fleming stated that he had in 1885 made some experiments with the Zipernowski transformers exhibited at the Inventions Exhibition, which were employed in running 200 16 c. p. lamps, the potential difference used in the primary being 1,000 volts. To prevent the danger, first pointed out by Dr. Hopkinson, of shocks from the electrostatic capacity of the secondary coil, he had proposed connecting one terminal to the earth, but on publishing the idea Professor Elihu Thomson had written claiming that he had devised this plan previously, and on this Professors Ayrton and Perry wrote, pointing out that they had anticipated Professor Thomson. Mr. Zipernowski had attempted the compounding of the transformers, and the results were fairly satisfactory. To determine the efficiency of the system they had used a couple of very large wattmeters which had a very low self-induction, the major portion of the fine wire coil being merely external non-inductive resistance, and with the results thus obtained the curve of efficiency shown on the wall had been plotted. Professor Ayrton had pointed out that the results thus obtained must be inaccurate, but it would be interesting to determine the amount of error. There was no question now as to the results of the magnetic lag. There was consequently a modification of the magnetic resistance of an alternating magnetic circuit analogous to that of the electrical resistance of an alternating electric circuit. The theory of transformers was in some respects simpler than that of the dynamo, as there was no air-gap to be taken into account; experiments should, however, be made on the permeability of iron at different periodicities.

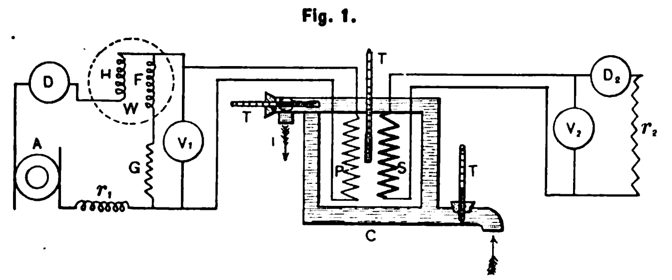
Mr. Crompton, as a commercial man, who was thinking of going into transformer business, wished to know from Mr. Mackenzie what the total efficiency of the whole system was. With regard to other methods of distribution, he could give figures for the efficiency of the system, from the coal in the furnace to the lamps, and if Mr. Mackenzie would do the same for the alternating current the two systems could be compared.

At the conclusion of Mr. Crompton's remarks the meeting was adjourned.

ADJOURNED DISCUSSION.

The adjourned discussion on transformers and the distribution of electricity by their means was resumed on Thursday, the 23rd ult., by Mr. Lamb, one of the gentlemen who had made calorimetric experiments with the transformer to which Professor Ayrton referred at the previous meeting. Mr. Lamb described the apparatus used, and exhibited some interesting efficiency curves, showing that the true efficiency of a transformer, as determined by the calorimeter, is throughout greater than the apparent efficiency determined by a wattmeter, or by the indications of a dynamometer and voltmeter. Figure 1, represents the transformer enclosed in the calorimeter, by which the true watts were determined. There were also in circuit the wattmeter, *W*, the dynamometer, *D*, and the voltmeter, *V*. The ratio between the reading of the wattmeter and the true watts was given by Professor Ayrton. The curve in figure 2, shows the true efficiency as calculated from

Fig. 1.



the calorimeter observations, and also the values obtained from the wattmeter. and from the product of the readings of the dynamometer and the voltmeter.

Mr. Gordon regretted that so much labor and ingenuity should be wasted on problems connected with alternating currents, because there was no future for them. He himself was one of the first to use alternating currents at the large installation put up by him at the Paddington railway station, and this system is still at work, with satisfactory results; but notwithstanding this success, he had come to the conclusion that the employment of alternating currents is beset with so many difficulties as to make the system unfit for general adoption. One of the objections is the large size of dynamo. He himself has constructed alternating current machines which were larger than any other machine produced up to that time, and although it may be very satisfactory for an engineer to see these huge armatures revolving, it was less satisfactory to the shareholders of the company. A 200 kilo.-watt machine would require an armature 10ft diam., whereas a 100 kilo.-watt low tension continuous current machine could be made with an armature only 16in. diam. Another objection to the system was that the whole of the power must be developed in one machine. He did not think it was possible to couple several alternate current machines together without producing considerable jumping in the lamps, which would, of course, shorten their life. Mr. Gordon exhibited an interesting diagram, showing that in a residential district the maximum number of lamps is only on for an hour and a half each day, viz., from 6 to 7.30 p.m., whilst from one-half to two-thirds of this number is on from 5 or 6 o'clock in the afternoon till 10 p.m. From 10 o'clock to about 3 a.m. the number of lamps alight steadily declines, and from 3 a.m. to 3 p.m. in winter it is only a small fraction of the total number fixed. The uneven rate of consumption is a great difficulty, because

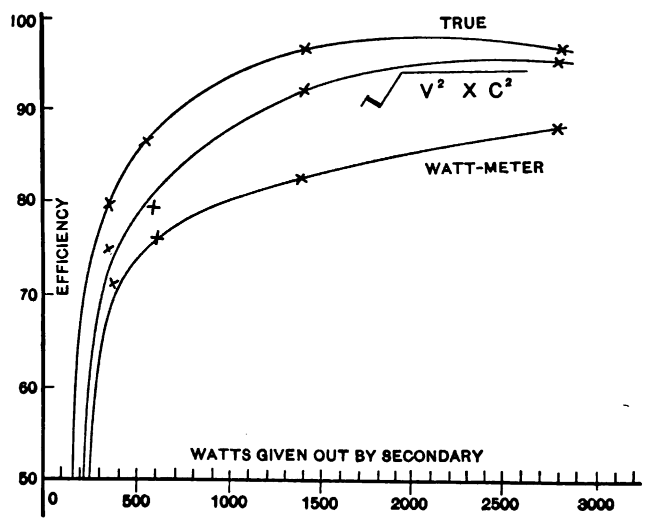
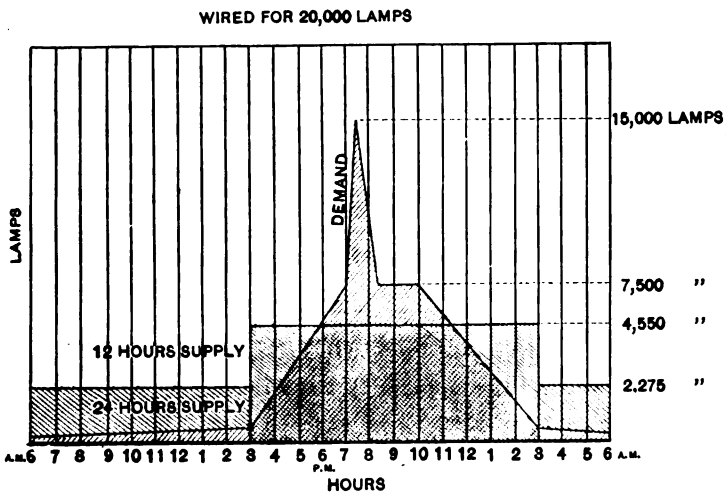


Fig. 2.

machinery must be provided equal to the large consumption, and the plant is therefore in excess of the requirements for twenty-two hours out of the twenty-four. Now let them see what would happen if they had storage batteries. Assume first of all that they were going to have a moderate amount of storage, and would work their machines for 12 hours. The quantity of electricity for the day was shown by the area of the demand curve; that showed the number of units—and the area of this second curve, or 12 hours' supply, must be the same as the area of this other curve, showing the quantity required for the day. If they had storage and worked their engines for 12 hours, the maximum current need only be a current for 4,550 lamps. The size of the engines, burners, and boilers was fixed by that. Therefore, for 20,000 lamps, with an occasional supply of 15,000 at once, it was not necessary to have, by storage, machinery of greater capacity than 4,550. If, however, they decided to work their engines for 24 hours—which might in some circumstances be advisable—they could then have something much smaller still. By this means small engines and dynamos only are required; but being kept at full work for a longer period, the total output is the same as with a larger plant spasmodically worked, whilst the efficiency is of course much higher. Engineers knew perfectly well that it was uneconomical to work engines much below their power. So convinced was he of the superiority of lighting by batteries, as compared with the direct system, that he was now engaged in putting up a central station at Whitehall place, where it will be possible to do what gas companies are doing, viz., to utilize the waste products. In this case the waste product is exhaust steam, which will be used for supplying hot water to the baths and heating apparatus of the residential chambers for which the central station is being erected. Mr. Gordon, after collecting statistics on the amount of gas lighting done in London, has found that there are about 125,000 gas jets to the square mile.

Mr. Crompton, who followed, spoke in the same strain. He thought Mr. Kapp's paper was rather dry, and he would therefore try to infuse a little life into the discussion by treating it from the commercial side. He did not deny that the transformer system had developed to a certain extent in America, but this was merely due to the fact that Americans would put up with any lighting, no matter how bad. It had also been developed to a considerable extent in London by the Grosvenor Gallery Company, and in this connection he thanked Sir Coutts Lindsay very cordially for being engaged in educating Londoners in the use of the electric light, and teaching them to put up with scintillations instead of good steady lighting. He thought that the clients of the Grosvenor Gallery could not be very fastidious, and it would be very easy for him or any other electrical engineer to satisfy their

demands in the future. As most of them knew, he had carried out central stations in which the transformation from high tension currents of 500 volts had been carried down to 100 volts, usually employed in incandescent lamps by means of four batteries in series. He had data from these installations, and data which were of use. It was no use in such a place as that to discuss the question of management—wages and matters of that kind—but it was of great use to discuss the engineering part of it, that is, the question of which system worked with the least horse-power, with the least first cost in machinery, the least first cost in mains, and the greatest steadiness and regularity and freedom from breaks down. From these points of view he proposed to compare the system of alternating transformers, with the system of battery transformers. At this stage he would remind them of the tremendous leg-up which the alternating transformer system had received from Mr. Westinghouse. Westinghouse was one of the most wonderful men in the world. There was no man like him as an organizer of labor and as an organizer of machinery. Witness his brake. In the face of the most tremendous opposition from the railway authorities he had made his brake almost universal, and he had done that with all these peculiar powers. He was a very rich man, and he had unexampled facilities at Pittsburg, where his most successful lighting had been carried out. But he would tell them that



what Westinghouse had done for the transformer system was exactly what Brush did for arc lighting in England a few years ago. He had turned out from a well-appointed factory complete, well-considered sets of machinery, packed and sent away to any township in America that wanted electric light of a sort. It could be put up in the way that American electric lighting machinery was done—very roughly—on the spot. But the things were so well appointed and so well made in the factory, that they could be erected at small cost, and in sufficiently good rough and ready fashion to suit the American taste. Anybody who had been in America, anybody who knew anything about American installations would confirm what he was saying—that electric lighting machinery in America as made in the shops was perfection; but the putting of it up was such as would not pass muster in the worst of our English installations. That had been the case with the enormous list of transformer machinery that had been carried out by Mr. Westinghouse. Although that was perfectly suited for such countries as America and Australia, countries where rough workmanship and such things did, it was quite unsuited for civilized countries. The moment they brought it into London, the moment that it was no longer a rover, as it was at present, over the tops of the houses, the moment they confined it under the streets, then it lost all its advantages. What were its advantages? Its advantages were that they could put down a station, and they could run wires anywhere they pleased, on account of the peculiar state of the law, and take up a number of customers that otherwise they could not reach at all. But he said that when the taste for electric lighting became more universal, when two in every three people along the line of streets took the light—that such a system of overhead mains and that kind of thing was intolerable; and there must come the day when mains had to be laid, as they had been successfully laid under the streets, and then they would find that the alternate transformer system was out of it as compared with the other. He did not believe that it was possible to work alternate current machines in parallel, and therefore it was necessary to do the whole of the lighting from one huge machine. This entailed a considerable waste of power when the demand for light was small, and therefore he thought that the average efficiency of the system must be exceedingly low. They were told by Professor Ayrton that the transformer he tested had a very high efficiency. That may be so, but what he wanted to know was the efficiency taken commercially, viz., from the coal bill to the money received for the sale of the current. This he ventured to say would be very unsatisfactory to the supplier of the electric light on the alternate current system. He drew attention to the last paragraph in Mr. Kapp's paper, where the author said that his net work of mains would be available for use with batteries if at a future time the change of system could be effected. He thought this showed that the author himself did not believe very firmly in transformers. The speaker had already adopted the battery system in several installations, and found it exceedingly economical. There was no need of employing currents of 2000 volts, as it was quite feasible to light a district a mile away from the generating station by currents of 500 volts, and yet to have comparatively small mains.

Mr. Esson did not think that the author's assumption regarding the curves of electromotive force and current were consistent with actual facts. He doubted that a dynamo which contained iron in its armature could give a true sine curve. This was shown on a wall diagram on which was drawn a true sine curve, and a curve calculated by Mr. Esson for a particular dynamo (figure 4). If, then, the curve be not a sine curve, the graphic method of the author, he thought, became useless.

Professor Perry dealt with the same subject, but came to a totally different conclusion. He thought the current given by any dynamo might with very little error be considered to follow the true sine curve. It was well known that a curve of any shape could be considered to consist of a true sine curve with other sine curves of the second, third, or fourth order superposed. Now the action of the transformer was to smooth down the ripples thus formed, and as this action was the stronger the more marked were the ripples. From this it followed that whatever may be the shape of the pole pieces or the disposition of the iron in the armature, the current passing through the transformer would follow very nearly a true sine curve. The difficulty of employing alternating current machines in parallel he did not think was insurmountable. It would be perfectly easy to contrive an instrument which would permit of the coupling up to be done only when the two machines have come into synchronism, and the same instrument might be used to regulate the power and speed of the engines, so as to maintain the synchronism.

Mr. Mordey could not agree with the author that it would be well to keep the transformers out of the houses, and to employ a proper low tension distributing network. He thought that by doing this one of the great advantages, viz., cheapness in distributing plant, would be lost. He would prefer to give each consumer his own transformer, or at the most to employ one transformer in common for two houses. Referring to the question of lag, he described an interesting experiment which apparently showed that there was no appreciable lag. In the first experiment he had two transformers. The thick wire terminals of the first connected with the dynamo, the fine wire terminals of the same transformer were connected with the fine wire terminals of the second transformer, and between the thick wire terminals of the second transformer would therefore be produced the same potential difference as that given by the dynamo. If now one of the thick wire terminals on each transformer were connected by a short wire, and a voltmeter was inserted between the remaining two thick wire terminals, this would indicate either the sum or the difference of the potential difference existing between each pair of terminals. If there were an appreciable lag the sum would be somewhat smaller than twice the potential difference of the

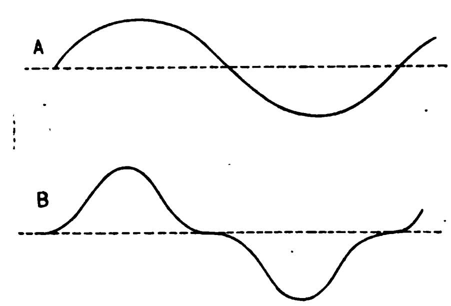


Fig. 4.

dynamo, and the difference would be somewhat greater than zero. If there were no lag the sum would be exactly twice the potential difference of the dynamo, and the difference would be exactly zero. To his surprise he found that this was actually the case, and even when he had coupled six transformers in the manner here described, the total potential difference over the whole series of six was exactly six times that existing between the terminals of the dynamo. This experiment seemed to show that there was no appreciable lag.

Mr. Wright could not agree with the author that the shell transformer was inferior to the core transformer. He himself had adopted the shell type because most of the heat was produced in the iron, and for this reason he thought it wise to place the iron outside.

Professor Silvanus Thompson thought the distinction of transformers into shell and core transformers was not a very definite

one, as it was impossible to say, in some cases, whether a particular transformer belonged to one or the other class. The graphic method of the author was certainly very simple and of practical use, because it enabled engineers who had no special mathematical training to solve problems connected with transformers. Mr. Esson's objection that the curve was not a true sine curve, he could not share. He had already, on previous occasions, expressed his opinion that the transformer is the very best possible apparatus for toning down the ripples in the curve, and altering its shape to that which corresponds to a true harmonic function. He thought that before high pressure service by means of continuous currents could be obtained, it would be absolutely necessary to improve the commutator of the dynamo. Mr. Crompton mentioned 500 volts as the highest pressure he intended to apply. This he thought an insufficient pressure if economy in mains was the object. The reason why Mr. Crompton adopted this low limit was simply that he could not get an ordinary commutator to work satisfactorily with a pressure of 2000 or 3000 volts. All the successful high tension machines had special commutators, but in the alternating system this difficulty was entirely overcome.

After a few remarks from Mr. Evershed and Mr. Kent, the President called upon Mr. Kapp to reply. The space at our disposal does not permit of our mentioning the various points touched upon in the reply, and we must, therefore, limit ourselves to that portion of it which had the greatest practical importance, because dealing with the comparative merits of the rival systems of supply brought forward at the meeting. Referring to the remarks made by Mr. Gordon and Mr. Crompton, the author did not dispute that distribution of electricity by means of secondary batteries was preferable to distribution by transformers; but before they could adopt the more perfect method it was absolutely necessary to have a reliable secondary battery. He himself had not met with such a battery, and if Mr. Crompton could bring one forward he should hail its advent with delight. All the arguments which were used by these two speakers on that evening might with equal reason have been used three or four years ago; but they were not used, simply because the speakers had at that time no confidence in batteries. If a battery could be put on the market which would be as reliable and as efficient as a transformer, and the cost of which would not be excessive, the author himself would be amongst the first to recommend its adoption for central station lighting, and that he did not doubt the ultimate discovery of such a battery might be seen from the concluding paragraph of his paper, where he advised that a secondary network should be laid down in the streets in such a manner as to be available for use with batteries at any future time. Mr. Crompton's objection regarding the inefficiency of transformers when these are worked at low output, was met by the diagram which Professor Ayrton had exhibited on the wall. They would see that even with an output as low as a third of the normal the efficiency was still 85 per cent. It would never be necessary to work transformers below this output, because if the consumption decreased sufficiently they would simply switch off certain transformers on the network, leaving the work to be done by a smaller number, which would then be worked to half or three-quarters their capacity. Great stress had been laid by Mr. Gordon on the fact that the maximum number of lamps was only on for a very short time during the day, and that the plant must, therefore, be very much too large for the supply required during the rest of the time, and also be worked uneconomically. The latter objection, he thought, had been met by some of the speakers, who showed that machines could be worked in parallel, and that it was therefore not necessary to do all the lighting with one huge machine. As regards the other objection, this applied equally to batteries, and where it was even of greater weight, because for equal output batteries were more expensive than engines and dynamos. The author's programme was to adopt transformers and alternating currents for the present, and to retain them only as long as they could not get a reliable battery. If they could get such a battery, he would advocate to discard the alternating current machines and the transformers. This would entail a loss of only 10s. per lamp fixed, which might be taken as the cost of dynamos and transformers; and when they considered that the central station, boilers and engines, the network, the house wiring, and the lamps would remain equally useful after the change, they would see that the loss entailed by the change was really very trifling.

The President then called upon Mr. Mackenzie to close the discussion. Owing to the lateness of the hour the reply was necessarily brief; but *Industries* was favored by Mr. Mackenzie with some notes of his written reply, which he sent to the secretary of the society, and the following is a short abstract: In reply to Professor Ayrton, who had asked whether compound winding of transformers had ever been tried at the Grosvenor Gallery, Mr. Mackenzie said that some experiments had been made with an apparatus consisting of a single coil of fine wire, placed in shunt to the primary of the series tranformer. The coil surrounded a core consisting of a bundle of iron wires, which could be more or less inserted to suit the requirements of the secondary circuit. The results were, however, unsatisfactory, the coils always being burned up after some time, and the idea was finally abandoned. Mr. Bernstein's suggestion of using a fusible contact plug as a safety device the author considered quite feasible. It would not only be cheaper than the apparatus devised by Captain Cardew, but it was also free from the objections which are justly urged against the proposal of putting any point of the secondary circuit to earth. In reply to Mr. Atkinson, the author said that fluctuations in the strength of the exciting current had been observed with the Kingdon dynamo, though these fluctuations were not very great. They were probably due to the cause mentioned by Mr. Atkinson. The author did not intend to convey the impression that the fly wheels of existing engines should be altered to suit the Kingdon dynamo, but that in designing new plant for a central station, the fly wheel of the engine, which is necessary to insure steady running, could be made to form part of the dynamo, and thus combine two functions in one. The object of arranging the machine into various circuits was with a view to cut out certain of these circuits as the consumption diminished, so that the remaining circuits would be worked at maximum efficiency. With reference to Mr. Crompton's question regarding the actual cost of working the Grosvenor Gallery installation, the author thought Mr. Crompton had asked rather too much. Many of his objections against the alternating current system had already been answered by other speakers. There could be no gainsaying the fact that the transformer system had made great headway, and this would never have been the case had it not possessed sufficient merits to place it before all others for the general distribution of electricity. The author himself expected to see Mr. Crompton before long become as warm an advocate of the transformer system as he had many years ago been an opponent of electric distribution by secondary batteries. Professor Silvanus Thompson and other speakers had taken exception to a statement in the beginning of his paper as regards the Faradaic theory. He wished to point out that neither he nor Mr. Gaulard had ever denied the Faradaic theory of induction; but Mr. Gaulard had from the first believed that this theory, as exemplified by Rhumkorff, was not a proper basis for the construction of transformers.

THE ALTERNATE vs. THE CONTINUOUS CURRENT.

The following letter appears in the *Western Electrician* of March 24:

In your issue of March 10, I find reported a paper read before the Chicago Electric Club on March 5th, upon "The Comparative Value of the Continuous and Alternating Current Systems, for the Commercial Distribution of Electricity," by Mr. H. Ward Leonard, in which paper, and in the discussion which followed it, some statements about our system here were made, which I desire to correct.

I do not intend to argue as an advocate of the alternating system: I have done enough in that direction at the electrical conventions. I only wish to correct false impressions which concern me individually as superintendent of this work.

Mr. Leonard speaks of the death of a telephone operator in Pittsburgh. This is simply not so. There has been no telephone operator or any one else in Pittsburgh killed by the alternating system. The instance to which he refers, and which has probably been misrepresented to him, was the stunning of one of the girls in the telephone exchange by a shock from one of the magneto bells used for calling subscribers. Surely Mr. Leonard does not, therefore, desire the telephone taken out of the house as a deadly menace to the lives of our mothers, wives and children.

We have a great many cases where we are operating 100 volt and 50 volt lamps from the same converter, though not necessarily on the three-wire system, but we have run 100 volt lamps on 50 volt converters, by putting the secondary mains in series, and the 50 volt lamps on 100 volt converters by putting the primaries in series; in fact, it is possible to obtain almost any combination with converters, which is in itself a very great convenience.

Mr. Leonard was "impressed" by our carrying a spare armature for our five large dynamos. We do. We also carry a spare armature for each size of our direct current machines, and several spare armatures for our arc machines. We also carry spare connecting rods for our engines, spare straps, brasses, keys, piston rings, etc., and spare tubes for our boilers; and so, I think, should every superintendent who has 15,000 lights on his conscience.

It strikes Mr. Leonard as being rather odd, that in the "home of the alternating system" we should find it necessary to establish two stations. Our company established, not two, but four stations, and why? Because with no practical continuous system could we operate our lights at the distance required. The first effect of the introduction of the alternating system was to completely wipe out one of these stations, of 1,800 lamps of 16 c. p. each, and to operate the whole from our central station. Will Mr. Leonard tell us how he would do this with the three-wire system, the distance between the station and centre of distribu-

tion in the building being 3,000 feet, and all the lamps burning at once, 12 hours per night? The second effect of the introduction of our alternating system is the stopping during part of the time of a second station of 1,500 lights average load, with the near prospect of its permanent shut down, and the removal of the machinery to our general station, the distance in this case being 13,000 feet from station to station. Will Mr. Leonard tell us how he could run this on the three-wire system?

The only reason that we do not contemplate the shut down of the third station is that "Station A," where we have established our business office, is in the centre of the city, and we cannot get room enough to put in the necessary power. We shall accordingly use "Station B" simply as a generating station, one mile from the heart of the city, and shall bring over from that station the necessary current for 10,000 16 c. p. lamps, distributing it from our central station, "Station A." Will Mr. Leonard tell us how he would tackle this case?

Mr. Leonard quotes very extensively from English electricians. I am a "Blarsted Britisher" myself, and do not hesitate therefore to remind Mr. Leonard what he surely heard Professor Forbes say at the Pittsburgh convention, that "In England they know very little about the alternating current system as compared to what is known here in America."

With regard to the danger of a connection between the primary and the secondary, does Mr. Leonard mean to say that a revolving armature with two windings on it side by side, which his description would seem to imply, is safer than the two stationary coils entirely separated from one another and from the iron core and case by mica, insulating tape and air space, which constitute the alternating converter?

Mr. Leonard says "I do not consider that the lamps, as they existed in that station at those long distances, were any more liable to be continuous than in the case of a series system, which of course can be operated at the same distance, and probably with equal results." The lamps, as they existed, were simply run from the second station, which has its dynamos shut down, and its bus wires, by the closing of a double pole switch, charged with current from our main station. Will Mr. Leonard tell us of a series system in which the individual lights can be cut off at the sweet will of the customers, with a corresponding decrease in current from the station?

I do not intend to enter into the question of the first cost of converters, as against the cost of copper, etc., with Mr. Leonard. By the use of the alternating system we are enabled to rent lights at a distance from our station of from two to three miles. As a consequence, without a single attempt at canvassing, we have increased our lights in eight months from 4,000 to 15,000 lights of 16 c. p. each; in one case, 1,800 lights in one building, 3,000 feet from the station; in another case, 1,200 lights 2,000 feet from the station; in another case, 800 lights 2,400 feet from the station; and on the same feeder, 300 at 12,000 feet from the station—all with less than 6 per cent. loss under full load from switch-board to lamp. Add to this that we can operate all of these from our "Station B," 5,000 feet further away, with only 5 per cent. additional loss. When Mr. Leonard has shown a case where a station operating the three-wire system has taken such contracts, *and stand ready to take them at any minute*, I shall be glad to discuss the commercial side of the matter with him.

I have not asked Mr. Leonard to answer any questions based on "average distribution over a radius of x feet" (all of which planning is very pretty on a map, but very little average distribution has ever come my way), but have placed before him certain cold blooded every-day problems which we have solved, without any trouble, by means of the alternating system.

I am sorry to have taken up so much of your space, but as superintendent of this company, I do not care to have it appear that after having used the direct current system, I should recommend any system which is not as practicable and economical.

T. CARPENTER SMITH,
Superintendent, The Allegheny County Light Co.

Pittsburgh, Pa., March 15, 1888.

THE COUNTER ELECTROMOTIVE FORCE OF TRANSFORMERS, OR CONVERTERS.

THE law formulated by Lenz, and its converse, as aptly put by S. P. Thompson, are that an induced current is always such that by virtue of its electro-magnetic effect it tends to stop the motion that generated it, and that the motion produced is always such that by virtue of the magneto-electric inductions which it sets up, it tends to stop the current.

Now, in a certain sense, a converter or transformer may be regarded as a stationary dynamo; only it is the *current* which is moved or alternated in polarity instead of the armature being moved mechanically. A corollary may therefore be deduced, which is that the induced current tends to stop the inducing current. That this tendency exists is not doubted, but perhaps we are hardly yet, all of us, beginning to realize to what an extent the phenomenon does actually occur. It seems at first sight scarcely credible that with a pressure of 1,000 volts at the terminals of the primary coil of a converter and only a few ohms of actual resistance in the coil, the current passing is reduced by self-induction to a small fraction of an ampere. One is so accustomed to the invariable application of Ohm's law that it is easy to forget the possibility of its being superseded or modified by another law, as it is in this case. If Ohm's law alone applied, such a volume of current would pass as would instantly fuse the whole apparatus.

We are referring, it will be understood in our present remarks, to an alternate current converter adapted for use in a constant potential circuit, the only one now used in practice. When these converters are connected in multiple, as is invariably the case, assuming them to be properly constructed, of course, we have a most beautiful system—a multiple system with a metallically closed circuit of perhaps less than an ohm's resistance, a pressure of, say, 1,000 volts, and yet no current passes! i.e. *practically* none.

So far we have assumed that no secondary circuit exists, and that the primaries alone are in operation. Here we should say that Ohm's law *does* in a certain sense apply; with 1,000 volts pressure, a closed circuit and no current there *must* be some resistance, and that *infinite*. This is, in fact, the case, but the "resistance" is not such as we have been used to call by that name. The counter-electromotive force of self-induction offers what is equivalent to resistance to the passage of the current, and with open secondaries this virtual resistance *is* practically infinite. Now, let us see what causes this, and in what manner it is modified by the action of the secondary coil. The primary conductor is of course, coiled upon a core of iron, and the current magnetizes this core. The magnetism thus produced reacts, and assists in inducing the current which tends to stop or stem back the impressed primary current. Self-induction would exist without iron, but the presence of iron enormously intensifies the action.

Let now the secondary circuit be closed through some resistance. What follows? A current will be induced in this secondary conductor of a volume, other things being equal, dependent upon the resistance of the secondary circuit, and this current will be in the opposite direction to that of the primary. It will therefore operate to *pro tanto* demagnetize the core. The counter E. M. F. or virtual resistance is thereby reduced, and more current allowed to flow in the primary. As an example, assume a transformer with a ratio of conversion of 20 : 1 — 1,000 : 50. The secondary being closed through, say 50 ohms, at 50 volts, 1 ampere will pass in the secondary, and 1-20 of an ampere in the primary. It will, therefore, be seen that there is then a counter effect in the primary which is equivalent to a resistance of 20,000 ohms. As the resistance of the secondary is decreased by introducing more lamps into circuit, and thereby increasing its current, its neutralizing effect also increases, until with 20 amperes in the secondary there will be 1 ampere in the primary, and a counter E. M. F., or virtual resistance of 1,000 ohms. There is thus an automatic sliding scale, the variations of counter E. M. F. in the primary following the variations in the secondary in a beautiful proportion. It is a pertinent question to enquire what would be the result of reducing the resistance of the secondary circuit to *nil*. It would be that an infinite current would flow in both the secondary and primary coils, the engine would be pulled up or *something would have to go*, and in practice it is this last which occurs, and therefore a fusible cut off is used as the thing which it is best to *let go*. Thus, when an accidental short-circuit occurs in the lamp circuit, the excess of current instantly melts the fuse in the secondary, or primary, or both, and the line is opened, no evil effect following save the extinction of the lamps.

In the above short sketch of one phase of the action of converters, we have not ventured into the labyrinth of scientific lore on co-efficients of self and mutual induction, waves of E. M. F. and current, *hysteresis* and the like, but have simply regarded the matter from a practical point of view.—*Modern Light and Heat.*

ELECTRICAL TRACTION.

IN the last two or three years a number of street car lines have been equipped with electric motors, and most of them have been successful in spite of the inexperience of those who have done the work,—an inexperience due to the newness of the field. The number of electric railroads under way is increasing rapidly, and for certain classes of work the motor seems destined to take the place of the expensive and overworked car horse.

As yet the greater part of the lines equipped have been for city tramways, generally in the suburbs, where there is comparatively little street traffic. This, however, is only a beginning, more useful in the experience it gives, and in the problems that are brought up and solved, than in the absolute results: for the question of the application of electricity to traction is a very broad one, and does not stop at street railways. The elevated railroads may be run by electric motors; already motor cars are

used in mines, where there is an extended field for their use; and it is possible that a few years will displace the steam locomotive, and substitute in its place powerful electrical locomotives.

There is no apparatus for the transformation of energy that compares in simplicity and efficiency with the dynamo-electric machine and electric motor. The steam engine transforms perhaps 15 per cent. of the energy of coal into mechanical work; while the efficiency of a good dynamo may be 92 per cent., and a motor may have as high an efficiency. If, therefore, we transform mechanical work into electrical energy by a dynamo, and retransform it to mechanical work again by a motor, we have a total loss of perhaps 15 per cent. It may be easily shown that in many cases it would be profitable, by taking advantage of the higher efficiency of large power plants, and the comparatively small cost of attendance, repairs, etc., per horse-power, to generate all the mechanical energy needed in a district at some central station, and distribute it by dynamos and motors to the consumers, displacing the small steam or gas engine plants previously used.

For traction work the problem is not to replace stationary steam engines or gas engines, but to replace horses, cables and locomotives. This problem is being attacked, and will doubtless be at least partially solved.

Before taking up the relative merit and costs of different systems, let us consider the broad questions that are involved. The questions are: (1) How can we best produce the electrical energy needed? (2) How can we best get it to our motors? and (3) After we get it there, what is the best way to apply it to traction?

Under the first head there are a good many things to consider, and many of these can only be answered by knowing the exact conditions of our installation. We can say generally that for a given horse-power needed at our motor we should so choose our source of power and location of generating station that the interest on first cost of plant and conductors (supposing we use them), the total depreciation, and the cost of the power *generated*, should be a minimum.

We will discuss these questions more fully when we come to the question of cost. To show the nature of the problem that might arise, suppose we have a railroad line from Philadelphia to New York to be run by electric motors. We would possibly find it best to have a number of generating stations along the line, at distances apart of, say, 20 miles. Now, if there were no natural sources of power near the tracks, we would have to calculate the best distances apart for these stations, knowing the cost for a horse-power with plants of different sizes, the cost of copper for conductors, the cost of a ton of coal at different points on the line, etc. The problem would not be a difficult one. If, however, there was at some distance from the line a source of natural power,—a waterfall, for example,—we would have to redistribute our stations, and calculate whether it would cost less or more to utilize the waterfall, decreasing the cost of power, in that we do not have to pay for coal, but increasing the size of plant for a given electrical energy at the line (for we must supply the needed energy *plus* the loss on our lines), and increasing the outlay in conductors. Of course, this is all a very definite question, presenting little difficulty to the electrical economist. When we consider that some railroad lines have distributed near them water-power capable of running all of their trains, with help at long intervals from steam generating stations (even windmills are not to be despised in some cases), and, when we further consider that the conditions are much simpler than in city traffic (we can use high potentials and unsightly devices if we choose), it encourages one to predict a future for electric railroads.

If, as we have so far assumed, we are going to transmit the electrical energy to the motors by conductors, it is evident that the potential we can use comes in as a factor. In cities we are usually limited to a comparatively low potential,—a maximum, say, of 500 volts. This has the effect of locating our generating station as near the line as possible,—in the middle of the line if we can get it there,—for the cost of conductors would be great if the station were too far from the line.—*Science.*

THE TELEPHONE DECISION IN BRIEF.

EXTRACTS FROM THE OPINION DELIVERED BY THE SUPREME COURT MARCH 19, AND PRINTED IN FULL IN THE SUPPLEMENT OF THE ELECTRICAL ENGINEER, MARCH 22.

THE ART.

THE question is not whether vocal sounds and articulate speech are used synonomously as scientific terms, but whether articulate speech is one of the vocal or other sounds referred to in this claim of the patent.

Electricity left to itself will not do what is wanted. The art consists in so controlling the force as to make it accomplish the purpose.

How to do it was the question. Bell discovered that it could be done by gradually changing the intensity of a continuous electrical current so as to make it correspond exactly to the changes in the density of the air caused by the voice.

This was his art.

He then devised a way in which these changes of intensity could be made and speech actually transmitted.

Thus his art was put in a condition for practical use.

The law does not require that a discoverer or inventor, in order to get a patent for a process, must have succeeded in bringing the art to the highest degree of perfection. It is enough if he describes the method with sufficient clearness and precision to enable those skilled in the matter to understand exactly what the process is, and if he points out some practicable way of putting it in operation.

This Bell did,

REIS.

It is not contended that Reis ever succeeded in practically transmitting speech, but only that his instrument was capable of it, if he had known how.

He did not know how.

All his experiments in that direction were failures.

With the help of Bell's later discoveries we now know why he failed.

We have not had our attention called to a single item of evidence which tends in any way to show that Reis, or any one who wrote about him, had in his mind anything else than that the intermittent current, caused by the opening and closing of the circuit, could be used to do what was wanted. No one seems to have thought that that there could be any other way.

It was left to Bell to discover that the failure was due, not to workmanship, but to the principle which was adopted as the basis of what was to be done

The true way was to operate on an unbroken current, by increasing and diminishing its intensity.

Such was his discovery, and it was new. Reis never thought of it, and he failed. Bell did, and he succeeded.

To follow Reis is to fail; but to follow Bell is to succeed.

The difference between the two is just the difference between failure and success.

Dr. Van der Weyde copied Reis, and it was not till after Bell's success that he found out how to use a Reis instrument so as to make it transmit speech. Bell taught him what to do to accomplish that purpose.

MCDONOUGH.

We presume it will not be claimed that he is entitled to more than he asked for, * * * a circuit breaker so adjusted as to break the connection by the vibration of the membrane. The patent office was clearly right in holding him to have been anticipated by Reis.

DRAWBAUGH.

Marx,—Klemm,—Levy,—Wolf.— * * On the 6th of March, 1880, these parties entered into an agreement.

On the 21st of July, 1880, Drawbaugh, claiming to have invented new and useful improvements in the transmission of vocal speech, * * assigned to Klemm, Marx, Wolf and Levy, the full and exclusive right to the said inventions.

On the morning of July 22, 1880, the following article appeared in the *Cincinnati Commercial*:—

"An application for a patent was filed to-day, that in consequence of its vastness of interest, as well as the wealth of prospect, renders it a subject of national interest. * * The cash capital of the company is $5,000,000 * * and in about 60 days will open up the telephone, which will certainly result in the driving out of all telephones in the market, save the ones they hold, or else in compelling the Gray, Bell and Edison lines to pay the new company a munificent royalty. * * It appears that the inventor of the telephone is a poor mechanic * * named Daniel Drawbaugh. * * A large number of capitalists * * assert * * that it will not be long till they have entire charge of the telephones, not only in this country but in the world, and that they will be able to establish lines by which messages can be transmitted for almost a song."

On the 30th of August, 1880, the People's Telephone Company was incorporated. On the 4th of September, 1880, Klemm, Levy, Marx and Wolf, in consideration of $4,999,550, represented by 99,991 shares of stock, assigned and transferred to that company all their interests.

At this time and in this way, the attention of the general public was called for the first time to the fact that Drawbaugh claimed to have anticipated Bell in the discovery of the telephone. Bell's success had been proclaimed more than four years before at the Centennial Exhibition in Philadelphia. Gray, Edison, Dolbear and others had either claimed for themselves, or others had claimed for them, priority of invention and discovery, and Bell had thus far been sustained as against them all. Blake had perfected his microphone apparatus, and Bell's patent had become a great commercial success.

The People's company either began, or threatened to begin operations, and on the 20th of October, 1880, the Bell company brought suit against it.

The bill * * avers that Klemm, Marx, Levy and Wolf, having heard that Daniel Drawbaugh * * had made some experiments relating to * * telephones * * entered into an

arrangement with him to set up and claim that he was the first inventor.

If Drawbaugh had ever made his pretended inventions * * "knowledge thereof has been withheld * * except so far as they have been disclosed within the three months last past by certain newspaper publications."

The People's company began taking depositions on the 19th of April, 1881, but Drawbaugh himself did not appear as a witness until December 7th, 1881.

All that any of the witnesses could say * * was that they had used one or more of the different instruments, and heard sounds and sometimes words * * and that Drawbaugh told them the sound was carried on the wire by electricity.

There was nothing whatever produced in print or in writing on the subject, nor even a memorandum or drawing of any kind, and there is nothing in the testimony to show that Drawbaugh ever told any one how his earlier instruments were made, or what his process was, until he was called as a witness in December, 1881. * * This was nearly 20 years * * after he had begun his experiment, nearly seven years after he had made and used * * perfectly constructed and finished instruments. It was also nearly six years after the date of Bell's patent, more than five years after the success of his discovery had been proclaimed at the Centennial Exhibition, * * four years after it had become an established success.

Under these circumstances it becomes important to consider the conduct of Drawbaugh in reference to his alleged invention during his 20 years of eventful history. * * If his present claim is true, he had in his shop * * telephones that were substantially perfect, months before Bell got the clue to his subsequent discovery.

The Centennial Exhibition was opened in May, 1876. Drawbaugh visited it on the 17th of October, 1876, remaining four or five days.

If what he claims now is true, he had then in his shop * * good instruments * * capable of transmitting speech, and some of them but just finished. * * Bell's apparatus had attracted marked attention. The matter was much discussed in the public press, yet it never seems to have occurred to Drawbaugh to take any of his telephones with him when he went, although they were small in size and some or all of them could have been carried without serious inconvenience.

He spoke to no one about what he had done himself. He made no special effort to find out whether that which was on exhibition was in any respect like what he had at home, neither did he, when he got home, * * * say anything to his neighbors or visiting friends about what he had seen or heard. He had apparently lost all interest in talking machines.

Not so, however, with his other inventions. * * During the early part of 1876, he was much interested in building an electric clock, which he thought of exhibiting at the Centennial.

On the 20th of September, 1878, he applied for a patent for improvements in batteries for electrical clocks.

On the 14th of January, 1879, he filed in the patent office an application for an improvement in rotary measuring faucets.

On the 2d of July, 1879, Drawbaugh filed another application for an improvement in water motors.

It is impossible to believe if Drawbaugh had in his shop when he reached home from the Centennial, exhibits D, E, L, M, G, O and H, or even D and E alone that he would have set himself at work in the first instance in developing the clock enterprise, or perfecting his former conception of the measuring faucet, instead of calling attention to his great discovery of the telephone * * which he could not but have known was even then attracting the greatest attention. * * No man of his intelligence * * * could remain silent under such circumstances.

It is not even pretended that he took any of these instruments outside of his own village until May, 1878.

Bell's success was proclaimed in the *Harrisburg Patriot* as early as February 26, 1877. * * If Drawbaugh had at that time in his shop the machines it is now claimed were there, complete as they now are, in August 1876, * * there cannot be a doubt that he would have taken them to some place where they could be tried, and show that they would do what he had all along claimed for them. * * It would certainly have been easier then * * to show that he antedated Bell, than it was three years afterwards, when he was brought into the controversy through the instrumentality of his associates, not, as must be evident to all, to get a patent for himself, but to defeat that of Bell.

From the time of his visit to the Centennial until he was put forward by the promoters of the People's company, nearly four years afterwards, to contest the claim of Bell, he was silent, * * while if he had really done what these witnesses say he did, he would certainly have spoken. There is hardly a single act of his * * * that is not entirely inconsistent with the idea of a complete discovery or invention by himself which could be put to any practical use.

But there is another fact * * equally striking * * F, D, C and I, were in no condition for use when produced and put in evidence. They were mere remains. No one but Drawbaugh could state how they were made or how they were to be used. He undertook to reproduce some of them. * * The Bell company proposed that they should be tried to see if they would do what the witnesses said had been done with the originals. * * * The proposition of the Bell company was accepted, and the reproductions tried in March, 1882, under the most favorable circumstances. It was substantially conceded that the trial was a failure.

To our minds the result conclusively shows that the original instruments could not have been of a construction similar to the reproductions, and that what they had done was produced by other means.

To hold that he discovered the art before Bell did would be to construe testimony without regard to the ordinary laws that govern human conduct.

POINTERS.

.... A SEPARATE engine for each dynamo machine is best. —*Dr. John Hopkinson.*

.... WITH first-class work I see no reason why underground wires should not be successful.—*T. Carpenter Smith.*

.... THERE is such a thing as leading an electric current into temptation.—*Alexander Bernstein.*

.... THE whole gist of the question of economical working lies in the study of graphic diagrams.—*R. E. Crompton.*

.... WE found out years ago that tin wire was the best material to use for safety fuses, and we have continued to use it ever since.—*R. E. Crompton.*

.... I think more nonsense has been talked about fuses and electrical fires than about any other subject whatever.—*W. B. Esson.*

.... THE competition with regard to small power lies between gas and electricity, and steam may be left out of the question.—*William Giessel.*

.... COMMERCIAL success in incandescent lighting depends primarily on the continuous, cheap, uniform and flexible generation of power.—*William Lee Church.*

.... THE contractor for dynamo machines should undertake to give a commercial efficiency of at least 90 per cent.—*Dr. John Hopkinson.*

.... AT every step, as I go through your different cities, I see how enormously ahead you are over us in England.—*Prof. George Forbes.*

.... ONE of the greatest sources of loss of power in fast running belts is the imprisonment of air between the belt and the pulley.—*Jesse M. Smith.*

.... IF people would only free themselves from the fetters of mere words, and look at actual facts, conditions and requirements, much more rapid progress would be made.—*Henry Dyer.*

.... AN American will generally accept the first solution of a problem and carry it into effect without loss of time, whereas an Englishman will always seek for some better solution, and end by not doing the work at all.—*M. Holroyd Smith.*

.... IN collieries electricity will be largely adopted in the near future. For underground hauling, pumping, ventilation and drilling, it can readily be applied at an efficiency double that of compressed air.—*William Giessel.*

.... IN designing supply works for electric lighting on a large scale, I am of opinion that the employment of a few very large dynamos instead of a larger number of smaller ones, is a mistake.—*J. Kenneth D. Mackenzie.*

.... THE idea underlying the transformer is the logical outcome of experience; but thus far we have no satisfactory application to general commercial uses, excepting possibly through the electric motor.—*W. J. Jenks.*

.... THERE is no more uneconomical beast on the face of the earth than a compound or triple-expansion engine worked down to one-fourth or one-fifth the total output.—*R. E. Crompton.*

.... I DO not know of any fires caused by electric lights which did not owe their origin to a disregard of principles laid down in the insurance rules of installation as essential for safety. —*S. E. Barton.*

.... I DARESAY that most of you know that the weak points of the insulation of our modern installations of incandescent lamps lie in the switches, fusing cut-outs and lamp mountings, and not in the wires themselves.—*R. E. Crompton.*

.... AN electric light station whose motive power is one or two large engines, finds itself in a position of earning money between starting time and 10 o'clock, and spending it again between 10 o'clock and morning.—*William Lee Church.*

CORRESPONDENCE.

NEW YORK AND VICINITY.

Underground Wire Enterprises Stimulated by the Collapse of Communication during the Blizzard, March 12 and 13.—The Board of Electrical Control.—Another Rapid Transit Scheme.—Electric Traction on the Fourth Avenue Line.—Trial of a Storage-Battery Car in Jersey City.—Electricity Proposed for Atlantic City Railways.—Impure Air from Pneumatic Tubes in a District Telegraph Office.—The Sheriff Enjoined from Selling Property of Several Telegraph Companies which have not Paid their Subway Assessments.—A Seaboard Cable Scheme to Head off Blizzards.

DURING the past month subterranean enterprises of all characters experienced a decided stimulus, for nearly every system of intercommunication above ground was paralyzed completely for 24 hours by the blizzard of March 12th and 13th. The process of recuperation has been slow, especially with telegraph and telephone circuits, for broken poles are not readily replaced. It appears almost certain that a serious outlay must be incurred, probably once in five years on an average, in repairing damages caused by either snow or sleet storms. If the electric light lines had suffered in an equal ratio no doubt considerable opposition to the underground scheme would be removed. As it is, the lighting companies will be very glad to see all of their neighbors' wires buried provided they are not disturbed.

The legal status of the board of electrical control is being gradually determined by the various decisions promulgated. Attorney-General Tabor has given his opinion that the board in this city is a state and not a municipal body. Mayor Hewitt may be considered responsible for raising this question, he having undertaken to bring the appointments by the board under jurisdiction of the municipal civil service rules. Another rapid transit scheme has made its appearance since the snow blockade, but was probably very fully matured before that event. The plan is a very comprehensive one, involving the purchase of a right of way on the west side, and the construction of a railway under the streets and blocks, and operated by electricity. Fireproof warehouses are to be erected on the land purchased by the company, and a necessarily large sum of money will be required to complete the work. As the amount of $1,250 has already been expended in payment of the state fee for organization, it is probable that the incorporators mean business.

The New York and Harlem Railroad Company, operating the Fourth Avenue horse railway in this city has made a formal applicationto the common council of the city for permission to substitute electric for horse power on its lines. It is generally known that a car has been run over this route for some little time past, with considerable regularity, operated by the Julien storage battery. There appears to be little doubt that the requisite license will be given, yet a public hearing will be granted on April 6th, to all who are interested either for or againt the project.

A trial trip of the storage battery car on the Jersey City and Bergen Railroad Company was not altogether satisfactory. It left the ferry with a number of passengers, but while on Grand street (Jersey City) there was a breakdown, and a consequent loss of some time before the car was able to proceed. As soon as these petty annoyances are overcome the company proposes to introduce electric propulsion generally on its lines.

The Pennsylvania Railroad Company is also said to be contemplating the substitution of electricity for horses on the Atlantic City railways.

One of the accompanying evils of a dense population is the occupation of unhealthy locations by human beings. Even the ordinarily impure atmosphere of a basement may be made worse by artificial means, and this complaint is made regarding the quarters occupied by the American District messengers at the Twenty-third street and Fifth avenue office. The pneumatic tubes from down-town open into the apartments, and the accumulation of sewer and illuminating gas driven through them is at times almost overpowering. Under the most advantageous circumstances a crowd of city messengers should be subjected to occasional fumigation, but a supply of fresh rather than foul air would tend to greatly lessen the evil effects of overcrowding.

Judge O'Brien of the Supreme Court has granted a preliminary injunction restraining sheriff Grant from selling the property of the Postal Telegraph Cable, the United Lines and the Commercial Telegram companies because they have not paid the assessments made upon them to cover the expenses of the subway commission. The state comptroller issued a warrant to sheriff Grant to collect the various assessments which, in the case of the Postal company amounted to $726, but it was not paid. the counsel of the company and its two associates having decided that it was levied in violation of the state constitution. There are several allegations made why the tax should not be paid. The comptroller had apportioned $50,000 for New York and $30,000 for Brooklyn. These amounts the companies consider unreasonable, claiming that $15,000 for this city and $9,000 for Brooklyn would be sufficient. It is also alleged that the assessment was made by the comptroller without having received a detailed statement of the expenses incurred by the board.

Some genius has proposed a system of submarine cables connecting the various important cities along the seaboard, so that electrical communication could be maintained in spite of blizzards. The practical utility of such a scheme would be doubtful during such a snow storm as prevailed on the 12th, for the reason that there was nothing which could be effectively done upon the receipt of telegrams. Business was practically suspended. First provide against the blockading of transportation lines, or, if considered expedient, establish subterranean lines giving an opportunity for communication with inland towns. An underground wire along each railroad line by which instructions and authority could have been given to agents and conductors, would have greatly facilitated the movements of trains during the late embargo.

NEW YORK, March 22, 1888.

PHILADELPHIA.

The Edison Electric Light Co. of Philadelphia; The First of Their Series of Stations.—The Suit of the City against the Baltimore and Ohio Telegraph Co.—The Philadelphia Electrical Society.—The Post Office Building Lighted by the United States Electric Light Co.—Retirement of Mr. H. Bentley from the Presidency of the Bell Telephone Co., of Philadelphia.—Mr. James Murray succeeds him.—Mr. W. B. Gill succeeds Mr. Murray in the Vice-Presidency.

THE Edison Electric Light Co. is about erecting the first of a number of electric light stations, which in a short time will supply both light and power to the entire city. The directors of the company are: Thomas M. Thompson, B. K. Jamison, Samuel B. Huey, Charles M. Swain, John Lucas, H. Blake Tyler, Edward H. Johnson, D. M. Lindsay and Amos R. Little. The company intends to furnish both light and power in large and small quantities. Sixteen candle power will be the standard size of lamp ordinarily used.

To understand the enormous scale on which the Edison Co. proposes to carry out its plans, a description of its first building somewhat in detail, will be necessary.

Its principal architectural feature is its great strength. The materials used are brick, stone and iron, the iron beams being of great size and weight, supported by heavy columns and pillars. This kind of construction is made necessary by the interior arrangement of the plant. The building will have a front of 70 feet on Sansom street, and will extend 100 feet back toward Walnut street. Its cornice will rise 114 feet above the pavement, overshadowing all the roofs in the neighborhood.

Twenty engines, of 250 h. p. each, will be placed on the first floor. Forty dynamos, with a capacity of 1,500 lights each, or a total capacity of 60,000 lights, will rest on the second floor. On the floor above the dynamos will be the workshops where wires and conduits are prepared for laying in the streets and making connections with houses. On the fourth floor huge boilers, with a capacity of 5,000 h. p., will be placed. In the fifth floor will be stored over 1,000 tons of coal at a time. The sixth floor, where light and air will abound, as its windows will look 20 feet above the roof of the Continental Hotel, will contain the general offices of the company and space for its clerical force.

This sounds like an amazing way of erecting a plant, with huge boilers and tons of coal in the air, but this reversal of the ordinary arrangement of machinery is due to the necessity of concentrating enormous power within a limited space. It also necessitates construction of the most massive kind, in the first place, the whole lot will be covered with a deep bed of concrete, four feet in vertical thickness. Resting on this bed will be the foundation walls, five feet thick. The 20 engines on the first floor, which will each hum at the rate of 200 revolutions a minute, are of the high-speed Armington and Sims type. They will each be firmly planted on a concrete monolith, 15 feet square. These 20 monoliths will rest upon a bed of sand one foot thick, which in turn rests upon the bed of concrete four feet thick. The dynamos on the floor above the engines will weigh seven tons each, and will make 650 revolutions a minute. They will rest on heavy iron beams supported by iron pillars, each pillar being capable of upholding 500 tons. Other pillars and beams support the floors above the boilers, furnaces and coal. The coal is to be driven upon scales, weighed and dropped into a pit. Chutes will be so arranged that the coal can be readily loaded on elevators and carried to the fifth floor. There the coal will be dropped into bins, from which a pipe runs at an inclination to the furnace of each boiler. All this machinery for delivering and feeding the fuel under the boilers will be strongly but simply designed to save time and handling.

On the third floor there will be placed two blast fans, capable of driving 50,000 cubic feet of air per minute into the furnaces. The smoke and other products of combustion will be carried from the furnaces into two chimneys of nine feet internal diameter. These chimneys, or smoke stacks, make an original detail of the building, for they will appear merely as bay windows, start-

ing at the third floor and reaching to the roof. These apparent bay windows will be at the rear of the building; the bay windows will contain spiral staircases. There will also be a passenger elevator in the front portion of the structure.

Pipes will carry the steam from the boilers to the engines on the first floor, and a huge exhaust pipe will rise from the engines to the top of the building. This exhaust pipe will be four feet in diameter at its top, and probably there is no exhaust pipe in use in Philadelphia as large as this.

Scientific appliances will be used to regulate the distribution of electricity and to secure perfect uniformity and regularity in the brilliancy of the lamps. Mr. Edison's inventions will be utilized in every possible way. There will be 35 great feeding mains running from the station. Each feeding main consists of three large bars of copper. To each of these mains a regulating apparatus is specially attached, so that the pressure is constantly kept at exactly the same point, whether one lamp or 1,000 may be burning on a main. In other words, this regulating apparatus keeps the quantity of current supplied to a main exactly proportioned to the demand.

When this great station on Sansom street is completed it will have cost the company about $1,000,000. This plant is only the beginning of the plans of the company. It will supply only the central portion of the city, and it is expected that other stations nearly, if not quite, as large, will be erected in Kensington, Richmond, Spring Garden, Northern Liberties, Germantown, Southwark, West Philadelphia and elsewhere. Already the company has expended $250,000 in copper conductors, 11 miles of which are laid under Chestnut and Walnut streets, between Twentieth and Fourth streets. During the coming summer 20 miles more of conductors are to be laid, extending between the Delaware and the Schuylkill, under Market street, from the Delaware to the Public Buildings, and on intersecting streets connecting with Spruce, Pine and South streets.

City solicitor Warwick held a conference recently with his assistants in regard to the case of the city against the Baltimore and Ohio Telegraph Co., to recover $50,000 for the alleged breach of the constitution in selling out to the Western Union Telegraph Co. Mr. Warwick declined to tell the result of the conference, however.

Councilman John H. Fow, who has been very active in the agitation of the matter since the alleged consolidation of the two companies, said that Mr. Warwick has two remedies: one would be to rule the defendant into court to show cause why judgment should not be entered for want of a sufficient affidavit of defense, and the other would be to rule them to plead and try the matter before a jury. Mr. Fow said that he was convinced that the city would recover the $50,000.

Nearly 500 persons gathered in the cozy rooms of the Philadelphia Electrical Society at Nos. 1712 and 1714 Chestnut street, a few nights since. It was the society's first reception. There was an interesting programme of vocal and instrumental music and recitations. An address of welcome was delivered by first vice-president John C. Sager. After the concert the spacious room was cleared and the members and their friends enjoyed a series of dances, with an intermission for refreshment. The society is composed of gentlemen engaged in electrical pursuits in this city. Though it is less than a year old it has nearly 200 members. The president is M. D. Law, of the Brush company; vice-presidents, John C. Sager, of the City Electrical Bureau, C. W. Knapp and H. B. Cutter, of the Pinkham company; recording secretary, G. C. Brooks, of the Adams' Express Co.; financial secretary, H. J. Curl, of the Baltimore and Ohio District Telegraph; treasurer, A. F. Reed, of the Baltimore and Ohio Telegraph Co.; board of managers, F. W. Griffin, American Telephone Co.; William McDevitt, Insurance Patrol; D. A. Curl, Baltimore and Ohio District Telegraph; R. J. Park, Pennsylvania Railroad; A. H. Manwarren, Brush company; A. W. Ford, Western Union; F. A. Lee, Philadelphia Local company; C. L. Chapin, City Bureau of Water.

The post office building has been supplied with a new electric light plant. There are seven dynamos in the cellar, driven by two engines of 150 h. p. each. They supply 3,000 lights of 16 c. p. each. The work has been done under the directions of superintendent E. M. Walsh, and has been going on for the past six months. The lighting is highly commended. The work was done by the United States Electric Co.

Henry Bentley has resigned the presidency of the Bell Telephone Co., of Philadelphia, and has been succeeded by James Murray, who was vice-president of the company. Wm. B. Gill, superintendent of the Western Union Telegraph Co., takes Mr. Murray's place as vice-president.

PHILADELPHIA, March 13, 1888.

BOSTON.

Public Electric Lighting in Boston.—Underground Conduit Schemes. Extension of the Police Signal System.—General Tearing up of Boston Streets.—The Output of the Bell Telephone Co.—The Boston Electric Club.—A Mysterious Fire.

ON September 27, 1886, the following order was passed by the board of aldermen:

Ordered, That the superintendent of lamps be and be hereby is authorized to contract with any responsible electric lighting company or companies, for furnishing the city with electric lights for public street lighting, for a period of not exceeding three years from the date of contract; the expense thereof to be charged to the appropriation for the lamp department;

and, under the authority of and according to the provisions of this order, contracts have been made with the Brush Electric Lighting Co., of Boston, the Citizens' Electric Light Co., the Merchants' Electric Light and Power Co., and the Charlestown Gas Co., for a period of three years from the date of said contract, viz., January 7, 1887.

The following is a copy of the contract as made with those companies:

This agreement, made this day of , A.D. 1887, by and between the Electric Lighting Co., a corporation established by law, having a usual place of business in Boston, Massachusetts, of the first part, and the city of Boston, of the second part:

Witnesseth:

That the said Electric Lighting Co. agrees to furnish electric lights, of not less than 2,000 c. p. each, according to the French standard of measurement, and to the satisfaction and acceptance of the superintendent of lamps of said city, in such number, and such places in the streets, lanes, parks, or other public places in said city, as the board of aldermen of said city shall from time to time direct, and keep the same lighted to the satisfaction of said superintendent, from sunset to sunrise of each and every night during the continuance of this contract, or during such hours of the night as the said superintendent of lamps may direct.

And said company further agrees to indemnify and save harmless said city of Boston from and against all claims and demands for damages, costs, expenses, or compensation for or on account of the erection, maintenance, or use of any of said lights, or of the wires or apparatus connected therewith; and also against any and all claims by reason of any infringement of any patent right in the use of said lights, or the apparatus or machinery connected therewith.

The said city of Boston agrees to pay for said lights, furnished and lighted as aforesaid, to the satisfaction of said superintendent, at the rate of 65 cents per light for each and every whole night the same are lighted; and at the same rate per hour of lighting, where, by order of said superintendent of lamps, such lights are lighted for a portion of the night only, and to make payment thereof monthly.

It is also understood and agreed that, in case of the failure or neglect of said company to furnish and keep lighted said lights, or any of them, as above agreed, there shall be forfeited and deducted from the sums to be paid by the city of Boston under this contract, an amount for each lamp or light so omitted to be lighted, equal to double the rate to be paid for lighting the same under this contract, as above provided.

This contract shall be and continue in force for three years from and after the day of , 1887.

It is also understood and agreed that, in case of any alteration of this contract, so much thereof as is not necessarily affected by the change, shall remain in force upon all the parties hereto, and no payment for any work done under any alteration shall be made until the completion of the whole contract; and the adjustment and payment of the bill then rendered for such work shall release and discharge the city from any and all claims or liability on account of any work performed under this contract, or any alteration thereof.

According to the municipal reports there were in use for public lighting:

	Arc Lights.
January 1, 1883	114
January 1, 1884	381
January 1, 1885	401
January 1, 1886	446
January 1, 1887	501
December 15, 1887	577

These lights are furnished by the following named companies:

Brush Co.	318
Weston Illuminating Co.	136
Charlestown Gas Co.	51
Merchants' Co.	27
Citizens' Co.	45
Total	577

The rate paid by the city is 65 cents per night, and the lights are used 365 nights per year.

On the 1st inst., Charles Babbidge and others appeared before the aldermanic committee on electric wires in advocacy of a petition to lay a conduit for running wires underground. J. M. Olmstead stated that the system for which the right was asked was what was known as the "solid" system, and made the offer to supply all the wires necessary for use by the city free of cost, which was more than any other system had offered to do. Henry C. Spalding, the inventor, said that by this way all wires were buried together in a mass, and that telegraph and telephone wires could be run in the same conduit. By his system there was a saving of space, and there was no necessity of tearing up the streets to any great extent. The committee took the matter under consideration.

On the 21st, police commissioners Whiting and Osborne were before the legislative committee on cities to ask that the amount that the board is allowed to take the coming year from the receipts of liquor licenses for the purpose of extending the police-signal system be increased from $75,000 to $150,000. The commissioners believed that the additional amount asked for would place the system in all the stations in the city, and that the most of it would come from the increase in license fees. They stated that some opposition to the system was manifest at the city hall, and for that reason the Legislature was asked to act. Mr. E. B. Welsh charged that the commissioners were using too much money, and that they did not need $150,000 when a system could

be put in for $100,000. Upon questioning it was brought out that Mr. Welsh had a rival system to those in use, and it was decided that the system to be adopted lay in the discretion of the commissioners.

City solicitor Bailey said that if the Legislature increased the city's burdens it should raise the tax limit; and the hearing was then closed.

With the conduit, hot water and cable road enterprises the streets of Boston are likely to be torn up for several years to come. The West End Railroad have applied for permission to put in cable roads; experiments were made last fall and early winter with the several motors operated by accumulater batteries; and President Whitney said before the board of aldermen that "The electric railway as yet had not been proven perfectly practical in all kinds of weather;" but that they were still experimenting with the matter.

The statement of the output of telephones by the American Bell company for the month ended Feb. 20, compares as follows with the statement for the same month of last year:

February—	1888.	1887.	Increase.
Gross output	3,972	3,405	567
Instruments returned	2,088	1,918	170
Net output	1,884	1,487	397
Dec. 21st to Feb. 20th—			
Gross output	8,002	7,379	623
Instruments returned	3,760	3,874	*114
Net output	4,242	3,505	737

* Decrease.

The Boston Electric Club has evidently come to stay, and is striking its roots deep into the ground; many who were indifferent or doubtful of the expediency of the use and utility of such an institution, are falling into line gracefully. On the evening of the 6th, Mr. George S. Page spoke before the club, upon "Combinations of Gas and Electric Lighting," to an applauding and appreciative audience.

The "great storm" of the 12th did not affect eastern New England as it did New York and the region round about; the telephone service has been good in Boston; some of the suburban lines are down, but, generally speaking, the loss of all kinds has not been anything comparatively. The long-distance copper line worked well to within a few miles of New York city; our local papers have been furnished news by the long-distance lines to the several points in New England, the telegraph lines being down. Hereafter it will not be in good form to refer to "cold and bleak New England."

The electric light in one of our fine business buildings, the "Simmons building," was on a rampage on the night of the 12th. Fire was seen to come from the recording resistance boxes inside the building, and it was discovered that the cut-out on the outside of the building was placed so high that no one could reach it. The pressure on the main line was supposed to be 500 volts, the current being furnished from a central station, and the boxes were supposed to be protected by safety fuses. The cause of the fire is obscure, and excites much interest in electric light circles.

BOSTON, Mass., March 16, 1888.

CHICAGO.

The Chicago Edison Company.—Mr. W. A. Kreidler in full Control of the Western Electrician.—Discussion of Continuous Currents vs. Alternating Currents by the Chicago Electric Club.—Dullness in the Electrical Supply Trade.—Rumored Purchase of Van Depoele Interests by the Thomson-Houston Co.—The Bell Telephone Co. of Missouri.—The Missouri and Kansas Telephone Co. Mr. Dorsett Still Engaged on Underground Schemes.—The City and Suburban Telephone Co. of Cincinnati.—Electric Light Wire Privileges in Cincinnati.—The Cincinnati Centennial Exhibition. —A Westinghouse Plant Ordered for St. Louis.—The Inter-State Telephone Co.—The Electric Light at Defiance, O.

THE Chicago Edison Company now announces officially that on or about May 1st lights will be supplied from the central station on Adams street to the district bounded by Franklin, Lake, State and Van Buren streets. This comprises the heart of the business part of Chicago, and there will be no difficulty for the Edison company to find a market for its 20,000 lights if the prices are low enough. It can be predicted with confidence, however, that the plant will not be in operation by May 1st, 1888, nor for some time thereafter. The building and machinery will not be ready by that time, although the work is now being vigorously pushed forward.

Mr. W. A. Kreidler has secured entire control of the *Western Electrician*. Under Mr. Kreidler's management his paper has made a remarkable success and has already established itself as an institution in which the electrical fraternity of the west particularly take a pride and interest.

The following announcement was sent out on March 2, by the secretary of the Chicago Electric Club :—The board of managers of the Chicago Electric Club have arranged for a discussion which will bear the general title—"The Continuous Current *vs.* the Alternating Current." Among those who will participate in the discussion are : Mr. H. Ward Leonard, of Leonard & Izard, representing the Edison system, who will advocate the continuous current; Mr. M. M. M. Slattery, of the Fort Wayne Jenney Electric Light Co., who will uphold the alternating current; Mr. E. P. Warner, of the Western Electric Co., who will argue for the continuous current; Mr. F. B. Badt, of the United States Electric Lighting Co., who will espouse the cause of the alternating current. The discussion will be inaugurated at the regular meeting of the club, Monday evening next, March 5th, by Mr. H. Ward Leonard, who will read a paper entitled "The Comparative Value of the Continuous and Alternating Current Systems for the Commercial Distribution of Electricity from Central Stations."

The success of this series of papers is shown by the largely increased attendance at the meetings of the club this month. The seating capacity of the club rooms has been completely occupied for the first time in the history of the club, and the interest in the discussions is such as to compel the chairman to terminate the debate abruptly when the hour for closing arrives.

It is reported by those engaged in the electrical supply and manufacturing business that trade is dull. Telephone companies are inclined to restrict orders to immediate requirements pending the announcement of the decision of the Supreme Court in the Bell patent. It is to be expected that electric lighting business will fall off at this season of the year, and an important factor in all branches of electrical trade is the high price of copper which materially restricts consumption. Since the syndicate (which now has control of the copper market) has secured the product of the Calumet and Hecla mines, confidence in an early return to moderate prices has ceased. It is evident that the syndicate has now absolute control of the copper market, and as it gives evidence of remarkable financial strength and seems to meet with some success in getting the general public interested in copper as an article of speculation and thus secures assistance in carrying its load, it would not be surprising if the price of copper should be higher than now, and it seems likely that the price will go no lower for some time. But with the immensely increased output from nearly all the mines in the world, and the largely reduced consumption resulting from the high prices, it is safe to predict that *some time* there will be a crash in the copper market.

It is announced that the Thomson-Houston Electric Co. has purchased the patents and stock of the Van Depoele Electric Manufacturing Co. At latest reports the bargain had not been completed; but as the Van Depoele company announces it there seems to be no doubt of the trade going through. As the most valuable part of the Van Depoele business is in the direction of electric motors and railways, this consolidation would seem to foreshadow increased activity in that line on the part of the Thomson-Houston Electric Co.

Mr. George F. Durant, general manager of the Bell Telephone Company, of Missouri, states that his company has secured a favorable lease of a building lot, and purposes following the example of New York, Chicago and Louisville in putting up a telephone building in St. Louis.

Mr. W. W. Smith, general superintendent of the Missouri and Kansas Telephone Company, reports a continuance of the remarkable growth of the exchange in Kansas City. Mr. Smith also claims that the Kansas City exchange has the best record as to the number of connections per operator per day. An absolutely accurate count gives the highest number of *completed* connections in 10 hours at 1659 for one operator, taking care of 100 subscribers.

The indefatigable Dorsett is now in Kansas City working for an underground ordinance. Numerous gas explosions have occurred recently in the Dorsett conduit in Chicago, fortunately without serious results.

The City and Suburban Telegraph Association of Cincinnati has the reputation among telephone people of giving good service at low rates and of keeping on good terms with the public. If proof of this were wanted it is furnished in the remonstrance signed by 90 % of the subscribers of the telephone company asking the Legislature not to meddle with the rates charged for telephone service. Public sentiment is so opposed to the bills now pending in the Ohio Legislature with reference to telephone rates that it is almost certain these bills will be defeated, as were similar bills which were introduced at the last session.

The Board of Public Works, of Cincinnati, is considering an ordinance granting to any electric light company the right of way over streets, alleys, and public grounds in Cincinnati, on condition of payment to the city of one per cent. of the company's gross revenue. It is predicted on good authority that this ordinance will pass.

The Centennial Exposition, which will open at Cincinnati on July 4th, will be lighted by 350 arc lights and 2,000 incandescent lights. The management has not decided yet what systems to employ.

The Excelsior Electric Light Co., of St. Louis, has ordered a 5,000 light Westinghouse alternating plant.

The Inter-State Telephone Co. has failed to secure the franchise for which it asked in the City of Chicago.

The Defiance Electric Light Co., Defiance, O., has decided to put in a United States alternating system.

CHICAGO, March 20, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 115 *Nassau street, New York city.*

ANTHONY AND BRACKET'S PHYSICS.

[89]. To the excellent reply of Mr. Jackson (In March *Electrical Engineer*) to criticisms on this Text Book of Physics, I wish to add the test of actual use, where it was designed to be used, in the college class-room. I have a class which has nearly completed the part on magnetism and electricity, and with some knowledge, from use, of several English, French, and American text books, I find Anthony and Bracket's the best for instruction in scientific and technological courses. I. THORNTON OSMOND.

State College, Pa., March 15, 1888.

THE JACK-KNIFE SWITCH.

[90]. It is sometimes amusing to read the errors of history, and trace the channel through which facts are discolored or mangled before their assuming a crystalized form. The hatchet and cherry tree story of good old father Weems, the fall of Newton's apple, the Tell and Gessler fable, all, with many another romance, are among the innocent fibs that, like Jack the Giant-Killer and the German fairies, go to make up the personnel of literary history. But when an author sets himself up as authority in matters of exact knowledge, in the line of science or mechanics, and lets his imagination lead him into romancing, the value of his work becomes, to say the least of it, rather doubtful.

The history of the Jack-knife switch, as well as the switch itself, was made in Chicago. The switch was a necessity to the system of telephone board in use by the American District Co., and the invention was more a matter of growth than of invention, and cannot be claimed by any one individual. It was the final outcome of several attempts to accomplish the transfer of the subscriber's line from the board to the operator's telephone, and had no less than two or three distinct forms before it was finally considered complete.

The invention has been claimed by two or three parties, and among these was a Canadian Frenchman, who at the time was superintendent of construction for the A. D. T. Co., which company opened the first exchange in Chicago. The knowledge of this claim of Mr. Rousseau was all that the story alluded to in the ELECTRICAL ENGINEER had for bottom facts The Parisian author unable to comprehend what a "Jack-knife" is, rounded out the innocent little fiction by assuming that Mr. Rousseau's front name was Jack. In justice to all concerned, it is but fair to say to-day that Mr. Scribner was principal inventor, while Rousseau was undoubtedly there as well as Scribner and others, and ready with suggestions of a practical nature, although his name is not Jack but Hector. C. C. H.

Chicago, March 22, 1888.

LITERATURE.

REVIEWS.

The Storage of Electrical Energy: BY GASTON PLANTÉ. Translated from the French by Paul Bedford Elwell. London: Whittaker & Co., 1887.

THE Planté lead battery has been a familiar subject in physical and electrical text books for upward of a score of years, and although the theory of its action was thoroughly understood, it was more than a decade after its discovery that an improvement by Camille Faure, in the method of preparing the plates, attracted universal attention to the practical utility of this remarkable cell. Previous to this improvement, although Planté had exhibited its unusual calorific effects, the battery had remained a sort of scientific curiosity, and, apparently had never been adapted to any commercial use; but it contained the germ of a serviceable instrument and, like many another well-known principle, only awaited a demand for its services to develop its practical worth.

The introduction of electric lamps, which required currents of greater quantity than could be conveniently and economically produced by the ordinary voltaic battery, created this demand; and the secondary battery emerged from the laboratory to enter the workshop, where the dynamo had already arrived.

From 1859 to 1879 M. Planté made hundreds of cells of his lead battery, and performed numerous novel and beautiful experiments by their aid. The results of his researches were given to the world in memoirs contributed to the Académie des Sciences, or published from time to time in various scientific periodicals. In 1883 these memoirs, after being considerably abridged and revised to include more recently discovered phenomena and applications, were collectively published in book form in Paris under the title of "Recherches sur L'Electricité," a demand for a better knowledge of the author's labors having, no doubt, been created by the much heralded improvement of Faure. The subject of this review is a recent English translation of the above work.

There are abundant examples of the akwardness characteristic of so many translations throughout the book, often resulting in obscurity. There is a rather long table of "errata," but on the whole the text is clear and concise. The book is divided into six parts treating respectively of: I—The Accumulation and Transformation of the Energy of the Voltaic Battery by means of Secondary Currents. II—Applications. III—Effects Produced by Currents of High Tension. IV—Analogy with Globular Lighting. V—The Rheostatic Machine. VI—Analogy Between Electrical Phenomena and Effects Produced by Mechanical Actions.

According to the auther, Gautherot, a French scientist, was the first to discover that platinum or silver wires which had been used to decompose saline water, possessed the property of generating currents of short duration after being disconnected from the battery. These so-called secondary currents were first observed in 1801, soon after the discovery of the voltaic battery. Many other scientists subsequently investigated voltaic polarization, as it was then termed, studying chiefly the currents obtained with platinum electrodes. In 1859 Planté undertook to compare the secondary currents produced by voltameters of various metals in different solutions, and although his apparatus as well as his methods would now be considered very crude—for instance he took no account of the internal resistance of batteries or voltameters—he produced the battery which bears his name, and much valuable information about re-action currents which these memoirs record.

The first chapter studies the secondary currents produced by different voltameters of the more common metals in acid and alkaline solutions, and the attending phenomena during and after the passage of a current is minutely described in a very thorough and instructive manner. At the outset, however, the reader who is familiar with the subject as it is understood to-day, is surprised to find that while the author acknowledges the probability of the absorption by, or even combination of hydrogen with the negative electrode of a platinum voltameter, as a partial cause of the prolongation of the secondary current, and goes so far as to presume that the hydrogen forms unstable combinations with the electrolyte, he deliberately attributes the cause of the same action in a lead voltameter wholly to the oxidation of the negative electrode. Now when a current is passed through a lead voltameter for a considerable length of time the positive electrode not only becomes visibly oxidized but so deeply that it turns almost black; when discharged, on the contrary, the negative electrode is only slightly discolored and even a casual observation will show that it is only very lightly oxidized. In view of the fact that Planté comments on his observation of these very points, it certainly seems strange that he should fail to perceive that the slight oxidation of the negative electrode is entirely insufficient to account for the quantity of the secondary current. It seems to be generally conceded at present, however, that the capacity of secondary elements is largely due either to a combination of hydrogen with the negative lead electrode or else to its occlusion within it. It is perhaps worth notice in passing that this same blunder has found its way into a paragraph descriptive of the secondary battery, in the recently published Physics of Anthony and Brackett.

The second chapter describes the several forms which Planté gave to his secondary elements and the best methods of forming and charging them, besides containing much information relating to maintenance which is applicable to batteries of the modern type. It seems strange to read here the statement that these secondary cells are well adapted to running motors *for a short time only*, when the author has already pointed out that the duration of the secondary current depends upon the thickness of the oxide which in turn is only limited by the thickness of the plates. Although later on he instances having charged cells with a Gramme hand magneto, it is evident that his dependence upon the ordinary small and expensive galvanic battery for charging them, was the factor which prevented him from recognizing the adaptability of his battery to supplying current in a large scale years before it was actually accomplished. The imperfect knowledge of the relation of electrical quantities to each other, possessed by prominent physicists only a few years ago, is well illustrated by a passage in this chapter to the effect that the quantity of electricity has more importance than its potential when opposed by external resistance. The duration and constancy of secondary cells are also investigated, as well as their efficiency and ability to preserve their charge. The analogies between their action and the effects produced by static condensers are also considered.

The second part of the work describes many practical applications of the secondary battery such as to galvanocausty,

illuminating cavities in the human body, firing mines, electric brakes, and even to electric arc lighting "for several minutes only."

The first chapter of the third part of the work deals with the effects produced by currents of high tension. Many curious and remarkable phenomena are described, which, however, would be similarly produced by high tension currents from any other source. The second chapter of this part illustrates a method of engraving on glass by electricity; and a very ingenious suggestion is made for a rock drill in which electric discharges are to disrupt the rocks.

The fourth part of the work discusses the analogies between the effects previously described and various natural phenomena, chiefly of a meteorological character, which leads to several interesting theories regarding such phenomena. The fifth part describes the once celebrated rheostatic machine, and the marvellous effects which it is capable of producing. This machine, which consists of a large number of small condensers arranged with a commutator, by means of which they may be charged in parallel and discharged in series, was designed by Planté for the purpose of transforming the energy of the voltaic battery so as to obtain an electromotive force equal to that of electrical machines. The sixth and last part of the book discusses some of the results obtained with these high tension currents, leading to mechanical analogies which suggest an interesting theory regarding the nature of electricity.

The first part of the book is undoubtedly a valuable contribution to the history of the evolution of the secondary battery, and is full of useful information regarding the nature of the chemical actions which arise in such batteries and of the fundamental principles underlying them. The remainder of the work is interesting and instructive, as the records of the labors of original experimenters always are.

CATALOGUES AND PAMPHLETS RECEIVED.

The United States Electric Lighting Co.—Western Department—C. C. Warren, manager, Chicago, send us a very clever and interesting circular recently issued. It contains a large number of letters from purchasers and users of the apparatus of the United States company, expressing their satisfaction with the performance of their plants in very complimentary terms. These letters are reproduced in fac-simile—reduced in size, and not only constitute a valuable tribute to the excellence of the electric lighting outfits of the company, but form (excluding those type-written) a rather interesting collection of specimens of Western chirography, several of which are uncommonly handsome. The covers are decorated with a series of pictures outlining, in a quietly humorous fashion, the history of illuminants.

Not the least striking feature of the circular is found in the object lessons on pages 26 and 27, the former exhibiting pictorially the gradual darkening of the globes of "competing" lamps, and the latter showing diagrammatically the growth of the business of the Western Department of the United States Electric Lighting Co., since its commencement in 1883.

The Brooks Underground Telegraph Construction Co., Limited, Philadelphia, issue a pamphlet of 17 pages, announcing their readiness under Patent No. 356,981, dated February 1, 1887, to grant, license, or contract to lay underground electrical conductors for every kind of service, and to guarantee the highest insulation and durability. The principal features of underground construction offered by the Brooks company in this pamphlet are the use of iron pipe as a conduit, and resin and resin oil as insulator and filling. Tables of a number of tests are given, showing high insulation with low inductive capacity.

The Lithographers' and Photographers' Directory, contains a complete list of all firms connected with lithography, photography and the graphic arts in the United States, Canada, Mexico, Central and South America. The book is published by The Lithographer Publishing Co., Fred Buehring, Pres't and Treas., at 12 Centre street, New York; price $3.

ELECTRICAL NEWS AND NOTES.

ANNUAL REPORT OF THE AMERICAN BELL TELEPHONE CO.

OFFICE OF THE AMERICAN BELL TELEPHONE COMPANY,
BOSTON, March 27, 1888.

To the Stockholders:

The business of the company for the year 1887 has been, on the whole, satisfactory.

The receipts for royalties show a reasonable increase; and the licensed companies, with few exceptions, have improved and extended their plant.

The statistics are given in the following tables:—

EXCHANGES.

—	1883.	1884.	1885.	1886.	1887.	1888.	Decrease from 1887.	Increase over 1887.
Exchanges	725	906	772	747	736	743	......	7
Branch offices	345	419	481	428	446	444	2	
Miles of wire on poles	....	....	88,481	100,332	111,349	127,902	......	16,553
Miles of wire on buildings	....	....	11,886	10,043	10,587	9,458	1,129	.
Miles of wire underground	....	....	1,225	3,417	6,080	8,009	......	1,979
Miles of wire submarine	....	....	....	254	265	363	......	98
Total miles of wire	68,571	85,896	101,592	114,046	128,231	145,732	......	17,501
Total circuits	74,484	97,422	107,440	112,067	121,260	131,896	......	10,636
Total employés	3,716	4,762	5,168	5,438	5,843	6,182	......	339
Total subscribers	97,728	123,625	134,847	137,750	147,068	158,732	......	11,664

EXTRA-TERRITORIAL LINES.

—	Jan. 1, 1883.	Jan. 1, 1884.	Jan. 1, 1885.	Jan. 1, 1886.	Jan. 1, 1887.	Jan. 1, 1888.	Increase during 1887.
Number of lines	247	598	896	897	911	927	16
Miles of pole lines	6,154	20,592	25,766	30,697	31,143	32,478	1,335
Miles of wire	13,653	29,359	35,631	41,745	43,767	56,179	12,412

UNDERGROUND WIRES.

Exchanges.	Jan. 1, 1886. Miles.	Jan. 1, 1887. Miles.	Jan. 1, 1888. Miles.	Increase over 1887. Miles.
Albany	....	1	1	....
Boston	289	347	736	389
Brooklyn	134	1,233	1,443	210
Chicago	760	1,462	2,000	538
Detroit	....	82	175	93
Louisville	....	9	238	230
Milwaukee	1	1	....	Loss 1
New York	627	627	1,120	493
Pittsburgh	614	966	958	Loss 8
Washington	992	1,302	1,388	86
	3,417	6,080	8,009	1,979
American Telephone and Telegraph Co.'s long-distance wires	....	....	140	140
	....	....	8,149	2,119

INSTRUMENTS.

—	Dec. 20, 1882.	Dec. 20, 1883.	Dec. 20, 1884.	Dec. 20, 1885.	Dec. 20, 1886.	Dec. 20, 1887.	Increase during the year.
In the hands of licensees under rental	237,728	298,580	325,574	330,040	353,518	380,277	26,759

EXCHANGE CONNECTIONS.

The estimated number of exchange connections daily in the United States is	1,011,517
Or a total per year of	369,203,705
The number of daily calls per subscriber varies in different exchanges from 3 to 14, the average throughout the United States being	6 37-100
As compared with	5 82-100

the number reported last year, an increase of 9 per cent.

The average cost to the subscriber varies according to the size of the exchange and character of the service, from 2 to 8 cents per connection.

EXTRA-TERRITORIAL CONNECTIONS.

The average daily number of extra-territorial connections is	6,796
Or a total per year of	2,480,540
The extra-territorial earnings for the year amounted to	$565,718 46
Of which this company's share is	76,076 36
An increase over 1886 of	459 06

In the case of five companies which have not reported December earnings, the amount is computed at the average of the previous 11 months.

The treasurer's statement shows—

Gross earnings from all sources		$3,453,027 70
Expenses		1,242,430 89
Net earnings		$2,210,596 81
Miscellaneous credits		27,011 31
Total		$2,237,608 12
Regular dividends paid	$1,176,252 00	
Extra dividend paid	392,084 00	
Total dividends	$1,568,336 00	
Reserve for depreciation of instruments	132,616 38	$1,700,952 38
Balance to surplus account		$536,655 74
Surplus account, Dec. 31, 1886		1,491,380 18
Total surplus		$2,028,035 92

The so-called government case, begun in January, 1887, came up June 18 for argument on our demurrer to the bill of complaint, and on September 26 the court sustained the demurrer and dismissed the bill. The government has taken an appeal to the Supreme Court, and a motion to advance the case for speedy hearing was made in October, upon which there has as yet been no decision.

The Globe Telephone Company, owning the Meucci claim, was finally enjoined in July. This case has also been appealed to the Supreme Court.

The case against the American Cushman Company is now ready for final hearing, and the directors have every reason to expect a favorable result.

In the cases before the United States Supreme Court on appeal (Dolbear case, Drawbaugh case, Molecular, Clay and Overland

cases, which, it will be remembered, were argued the latter part of January and the first of February, last year) a decision was rendered on the 19th March current. The opinion was by Waite, Chief Justice. All the cases on all points are determined in favor of the company.

The scope of the patent for which we have contended was sustained by the court. Mr. Justice Bradley, in behalf of himself and Justices Field and Harlan, expressed an oral dissent on the question of fact concerning Drawbaugh's priority of invention. Otherwise the opinion of the court expresses the unanimous opinion of all the members of it.

Bills for the regulation of telephone rates have been again introduced in a number of state legislatures, but the result of the Indiana legislation has been so unsatisfactory to the subscribers, and the inexpediency of so crippling the companies that they would not be able to give the best possible service is so obvious, that we may hope that no such measures will be adopted.

The committee appointed by the legislature of the State of New York to investigate telephone charges has reported a bill limiting rates for combination line service in cities of over 1,000,000 inhabitants, but the report of the committee itself furnishes the best arguments against the passage of such a bill, recognizing, as it does, the great cost of underground work, and the frequent changes in switch-boards, cables, etc., made necessary by the rapid strides in electrical inventions.

The long-line service has been extended from New York to Albany, and to Boston, making a total of 550 miles of pole lines and about 10,000 miles of wire.

The success electrically, as well as commercially, has been beyond our expectations.

The income from the long lines is now more than sufficient to meet the current expenses, and there is every reason to expect that before next year it will pay a moderate profit. The great cost of the plant is to be borne in mind in considering the direct profit from the long-line service, but the importance of the system as a safeguard to our business cannot be overestimated.

It is intended to complete this year the lines between New York and Boston, to extend from Albany towards Buffalo, and to build a line from Chicago to Milwaukee. The estimated cost is about $1,000,000.

The patent division has continued its work of collecting, digesting and studying information upon electrical matters, and preparing reports upon questions submitted to it by officers of the company.

It has also during the year considered and passed upon specifications for inventions for which the Western Electric Company intend applying for patents.

The electrical division has been mainly occupied in investigation for the accumulation of technical information for the use of our counsel. It has also begun, and is now pursuing, a series of experiments on multiplex telephony and on simultaneous telephony and telegraphy.

The mechanical department has experimented with a large number of instruments sent to it for examination, and it has also given much time to experimentation with a view to the improvement of our standard instruments, and to the solution of the problems which have been brought out by the long-line service.

Considerable time has also been spent in the study of magneto transmitters and in devising different forms for local uses.

On the first of September the company suffered a serious loss in the resignation of the president, Mr. Forbes. At a subsequent meeting of the board of directors the following resolutions, reported by Messrs. G. G. Hubbard, Cochrane and Sanders, a committee of the directors, were unanimously adopted, and ordered to be presented to the stockholders:—

"*Whereas* our associate, Mr. Forbes, was chosen president of the National Bell Telephone Company at its organization on the 11th of March, 1879, and continued in that office until the merging of that company into this the American Bell Telephone Company, and has been the president of this company since its organization in April, 1880, to the date of his resignation, in September, 1887; and

"*Whereas* during this long service the telephone business has grown in a most remarkable manner, the net income having increased from less than $2,000 per annum to about $2,200,000, and the number of instruments in use from about 21,000 to 375,000; and

"*Whereas* the vast and unparalleled litigation which this company has been forced to undertake, and the many and various interests occasioned by the system of licensing persons and corporations in every part of the country, and the intricate relations with the Western Union Telegraph Company and others have demanded qualities of an unusual character; and

"*Whereas*, Mr. Forbes has given constant attention to the interests of this company, and has displayed eminent ability, great dignity, uniform fairness, courtesy, and great tact in grasping the main points of the questions that have come before him, and has thereby won the confidence of his associates, of the licensees of this company, and of those with whom he has been brought officially in contact; and

"*Whereas*, Mr. Forbes, by these qualities, as well as by the marked moral courage and pluck exhibited on several trying occasions, and by his excellent judgment, has largely contributed to the success of this company;

"*Therefore resolved*, that the thanks of the directors be and they hereby are given to Mr. Forbes; and that this preamble and resolution be recorded in full in the minutes of the board, and a copy be presented to the stockholders at the annual meeting of this company.

"GARDINER G. HUBBARD.
ALEXANDER COCHRANE.
THOMAS SANDERS.
FRANCIS BLAKE.
GEO. L. BRADLEY.
CHARLES P. BOWDITCH.
CHANNING CLAPP.
CHAS. EUSTIS HUBBARD.
JOHN E. HUDSON.
CHARLES E. PERKINS.
H. STOCKTON."

The books of the company have been examined four times during the year, and the reports of the auditing committee are appended.

For the directors,
HOWARD STOCKTON, *President*.

LEDGER BALANCES, DEC. 31, 1887.

DEBTORS.		
Telephones	$663,081 93	
Stocks and notes	23,233,975 03	
Merchandise and machinery	8,730 11	
Bills and accounts receivable	640,615 48	
Cash and deposits	59,211 25	
CREDITORS.		
Capital stock		$9,802,100 00
Bills and accounts payable*		470,402 71
Patent account (profit and loss)		8,554,752 18
Profit and loss		3,365,018 63
Reserves		385,304 36
Surplus		2,028,035 92
	$24,605,613 80	$24,605,613 80

* Of this amount, $294,068 is the dividend payable Jan. 14, 1888, to stockholders of record Dec. 31, 1887.

WM. R. DRIVER, *Treasurer*.

BOSTON, March 27, 1888.

COMPARATIVE STATEMENT OF EARNINGS AND EXPENSES.

	1886.	1887.
EARNINGS.		
Rental of telephones	$2,103,492 44	$2,264,823 94
Dividends	844,555 76	1,013,036 99
Extra-territorial and branch lines	78,109 81	80,443 67
Telegraph commission	16,681 22	19,962 31
Interest	34,560 77	70,235 68
Miscellaneous	13,600 91	4,525 11
	$3,097,000 91	$3,453,027 70
EXPENSES.		
Expenses of operation	$230,968 05	$242,205 06
Legal expenses	210,550 20	207,679 95
Interest and taxes	82,458 25	139,174 80
Commission	404,111 30	433,578 87
Royalty	14,501 36	11,000 00
Rental concessions	207,128 63	189,765 38
Miscellaneous		19,027 33
	$1,149,717 79	$1,242,430 89
Net earnings	$1,947,283 12	$2,210,596 81
Misc. items to surplus account	26,067 64	27,011 31
	$1,973,350 76	$2,237,608 12
Surplus account, Dec. 31, 1886	$1,491,380 18	
Net earnings, 1887	2,210,596 81	
Miscellaneous items	27,011 31	$3,728,988 30
Regular dividends in 1887	$1,176,252 00	
Extra dividend in 1887	392,084 00	
Reserve for depreciation of instruments	132,616 38	1,700,952 38
Surplus account, Dec. 31, 1887		$2,028,035 92

THE TELEPHONE INVESTIGATION.

THE NEW YORK ASSEMBLY COMMITTEE'S REPORT.

The committee appointed by the New York Legislature in April, 1887, to investigate the business of telephone companies in the state, presented a report March 6th, 1888.

The committee find that the American Bell Telephone Co. is a corporation organized under the laws of Massachusetts with a capital of $10,000,000, which owns and controls all patents now in use upon telephonic instruments in the United States. Except as a large stockholder in local companies, it does not operate in this state. It does not sell any of the instruments manufactured under its patent, but leases them to its licensees at an annual royalty of $14 per set, excepting the Metropolitan company of New York and the Commercial company of Troy, which it charges $10, reserving the right to increase all these royalties. In addition to these royalties it also exacts from its licensees a

further consideration in the form of a donation of 35 per cent. of the capital stock of its licensees. It also exacts a commission upon an extra territorial and telegraph business done by the licensees of 15 per cent. of the former and 50 per cent. of the latter.

In respect to companies in the vicinity of New York, the committee finds that the Westchester Telephone Co. operates portions of Westchester and Rockland counties, and was organized in 1882, and has a capital stock of $300,000, all of which has been issued and $100,000 of which is owned by the American Bell company as franchise stock. Its cost of construction is $372,196.07, and its net earnings for the past fiscal year were $13,937, showing a percentage of net earnings to cost of 3.7 per cent. The remainder of its stock has all been purchased by the Hudson River company. Its average dividend since organization has been two per cent. It has 1,006 subscribers.

The Staten Island Telephone Co. operates Staten Island, and is a sub-licensee of the Metropolitan company. It was organized in September, 1883, having a capital stock of $135,000, all of which has been issued. Its cost of construction is $81,586.58; its net earnings for its past fiscal year were $6,474, showing a percentage of net earnings to cost of 7.9 per cent. The Metropolitan company own $45,000 of its capital stock, issued to them as franchise stock.

Its annual dividend has been five per cent. It has 272 subscribers paying from $60 to $120 per year, depending upon distance from central office.

The New York and New Jersey Telephone Co. operates Long Island, Brooklyn, Jersey City, and outlying points. It was organized in 1883 with a capital stock of $2,400,000, all of which has been issued. It is a sub-licensee of the Metropolitan company which owns $800,000 of its stock. Its cost of construction is $1,709,000, and its net earnings during the past fiscal year were $185,766, showing a percentage of net earnings to cost of 10.8 per cent. It has 5,317 subscribers, at an average rental of $70.56. This company has a special class of service furnished to 65 subscribers who are large users, at an increased rate of $720 per year. One subscriber, by actual count, has 18,000 connections with New York city alone, aside from his local use of the instrument. Another found by actual record kept, that his telephone was used four hours and 30 minutes out of seven business hours, counting from the moment it was being connected with subscriber to the moment it was released. "These instances illustrate the inequity of a state uniform rate," says the report. These cases exist to a less marked degree throughout the state.

The Metropolitan Telephone and Telegraph Co.: The committee review the conflict between the Western Union Telegraph Co., as owners of the Edison patent, and the Bell company, as owners of the Graham Bell patent, out of the settlement of which grew the Metropolitan company, of New York. This company was organized in May, 1880, with a capital stock of $1,000,000, owned respectively by the American Bell company of Boston, and the Western Union Telegraph Co. in the proportion of 60 and 40 per cent. It operates Manhattan Island only, although the territory operated by the Westchester company, the Staten Island company and the New York and New Jersey company was originally embraced in its franchise. The royalty paid by the Metropolitan company to the American Bell company is $10 per instrument per annum. Its cost of construction is $1,871,116.94, $426,729 of this having been expended in the erection of the company's new building at No. 18 Cortlandt street. This the committee have disregarded in basing its percentages, upon the ground that it had not been occupied during the time embraced in its receipts and disbursements, and thus had not contributed towards its net earnings. Its net earnings for its past fiscal year were $576,055,80, showing a percentage of net earnings to cost of 39.88 per cent. It paid no dividends in 1881 or 1882, and the dividend for its past fiscal year was 10 per cent. Its earnings for the year ending March 31, 1886, were: Private lines $187,737.31, district exchanges $800,072.50, telephone rentals $108,212.76, tolls $60,548.75, miscellaneous sources $15,222.64, total $1,171,793.96. Its expenses were: Operation $458,151.71, reconstruction $48,654.-43, instrument rental, American Bell Telephone Co., $165,758,27; rental Manhattan plant, $16,500; rebates, $1,750,79; roof rentals, $6,745.88; taxes, $12,000; insurance, $3,000; legal expenses, $13,-500; miscellaneous, $2,315.19. Total, $728,376.27. Their average number of subscribers for the past year was 6,101, at an average annual charge of $149.83

The total number of subscribers to telephone exchanges throughout the state is 26,240. The total capital stock of the companies doing business in the state is $8,395,000. The total cost of construction of the plants of the various companies throughout the state is $5,780,978.43. The total net earnings for the past fiscal year were $1,028,233. The average capitalization per subscriber is $319.93. The average capitalization throughout the United States is $351 per subscriber.

The committee deal at length with the problem of underground construction, which they have met in Brooklyn, Buffalo, and New York. They present an exhaustive brief summarizing the federal and state decisions in a large number of states, upon the right of the legislature to regulate the charges of local companies, and find that they have such right; also, upon the right of the legislature to regulate the royalty charged by the American Bell company, of Boston, and find that they have not the right to regulate them. The committee review the investigations in Rhode Island, Connecticut, Maine, New Hampshire, New York, Pennsylvania, Ohio, Michigan, Minnesota. Illinois, Indiana, Iowa, Arkansas, and Texas, with regard to this question, and review at length the legislation upon this question in Indiana, and its effect both upon the companies and the people. They treat of the various patents owned by the American Bell company, and the interference between the caveats of Mr. Berlimer and Mr. Edison, arriving at the conclusion that, at the option of the American Bell company, its present monopoly upon telephonic instruments for practical use will extend for a period of 17 years from the date of the settlement of this interference. The only means to defeat this monopoly will be the invention by another person of a telephone which shall render communication possible by means of what is known as the "make and break" system, which, electricians say, is extremely doubtful.

The committee think there is but one circumstance which in their judgment would justify legislative interference; that is the imposition of a charge so large that it shall be a burden to those who use the telephone, and which shall produce a revenue disproportionate to that return to which its inventors and those who put their money into it when it was an unsolved problem are entitled. That circumstance is found in the cities of New York and Troy; in the case of the latter its franchise expires so soon that no legislation is recommended for that city. They believe the returns of the Metropolitan company are larger than they have a moral right to demand, and submit a bill making the charge in New York city $6.50 per month, with an added mileage of $2 per month for all points exceeding one-half mile from any one of its present central offices.

Two bills accompany the report of the Telephone Investigation Committee. The first limits the issue of stock and creation of lines by incorporated companies, and is as follows:

Sec. 1. No share or shares, stock or certificate of stock shall hereafter be issued by any company organized or chartered by or under the laws of this state, except upon previous payment in cash of the par value thereof, or upon condition of service equivalent in value to par value thereof. A record shall be kept by each company of all payments for stock which shall show in detail the date and amount of each payment, the kind, amount and value of the service rendered for which any stock is issued, the amount of stock issued, where and to whom; which record shall be open at all times to stockholders of and any person dealing with such company for inspection.

Sec. 2. No bond, mortgage, or other evidence of indebtedness shall be issued, given, or made whereby any lien upon any of the property of any company created or incorporated by or under the laws of this state is, or is assumed to be, created, until a statement in writing has been made and duly verified by the oath of the president, secretary and treasurer of the company, or a majority thereof, showing that the capital stock of such company has been actually paid in, and such statement so verified has been filed in the county clerk's office, where the principle business of such company is transacted; and any wilful misstatement or false statement contained therein shall be perjury, and punished as such.

Sec. 3. Any officer or other porson who shall issue or assume to issue any share, stock or certificate of stock, or who shall make or execute any bond or mortgage; or cause any indebtedness whereby any lien is or is assumed to be created, contrary to the provisions of this act, is guilty of a misdemeanor, and upon conviction liable to a fine of not more than the par value of the stock or shares issued or lien created, or assumed to be created, or by imprisonment in the county jail for not more than one year, or by both such fine and imprisonment.

Sec. 4. This act shall take effect immediately.

The second bill regulates telephone charges in cities of 1,000,-000 or more inhabitants, limiting the price of instruments within one-half mile of the central office in such cities to $6.50 a month, with $2 a month additional for each additional half mile of distance. A penalty of $50 is provided for every violation of the law. The act to take effect June 1st.

AN EXTENSIVE ISOLATED PLANT.

The reconstructed building of the Equitable Life Assurance Society at 120 Broadway, New York, now nearly completed, has been fitted with an isolated incandescent electric light plant, which is probably the largest one in the world. It will be remembered that in this building some of the first, if not the very first, incandescent lamps ever seen in New York city were put in service by the United States Electric Lighting Co.

The steam and electric plant is located in the basement of the building in a spacious apartment fitted up in a neat and substantial manner, with concrete floors and walls of glazed tiling. The steam plant comprises one 500 h. p. Corliss engine for general service, and a 75 h. p. Armington & Sims engine for special and night service; nine boilers, each of 100 h. p. capacity, supply steam for operating the electric plant and running the elevators and pumps, as well as heating the entire building.

The electric current for lighting is supplied by a group of seven 600-light Weston dynamos, which ordinarily are separately excited by an independent dynamo, although switches are so arranged that their field circuits can be detached if emergency requires from the independent dynamo, and connected either with the main leads or with any particular dynamo of the system. The general field circuit of all the dynamos is controlled by an automatic regulator.

The building is wired for 7,000 16-candle incandescent lamps.

These are arranged upon six main circuits, which are carried through the elevator shafts, and are connected by feeders with the main switchboard in the dynamo room. The local branches on each floor are concealed within the walls, and usually carry about 30 lamps each. The fall in potential is calculated not to exceed 2 per cent. when the full number of lamps are in service.

Some idea of the dimensions of this plant may be gathered from the fact that it has more than half the capacity of the Pearl street central station of the Edison Illuminating Co.

The complete and thorough manner in which this immense installation has been carried out, as well as the brief time which has been occupied in the work are deserving of special commendation. The entire plant and fittings were supplied by the United States Illuminating Co. of this city.

THE HERZOG TELESEME ADOPTED BY THE NEW YORK POLICE COMMISSIONERS.

The Herzog teleseme system for police signaling has been on trial in the Nineteenth Precinct, New York, ever since last August, and, in voting, March 8, to adopt it for general use throughout the city, the police commissioners cited the fact it has been subjected to working tests in all kinds of weather, and is the only system that fully meets all the requirements of the service.

Mr. F. Benedict Herzog, the inventor, is to be congratulated, not only upon his ingenuity in devising and perfecting his system, but also upon the success which has crowned his energetic and persistent work in securing the adoption of the teleseme for the police service of New York.

AN INGENIOUS MESSAGE-HOOK AND LETTER-FILE.

The Harpoon Security Message Hook, illustrated below, seems to be a very clever device for filing telegraph messages or letters. It has been recently introduced by The E. S. Greeley & Co., New York..

The illustration requires little if any explanation. The security device in this hook consists of a gravity barb or tongue pivoted at one end, which drops naturally into the position shown in the engraving. In filing a paper on the hook, the barb or tongue is forced up into a slot and allows the paper to slide freely along the hook, making only a small round hole without tearing it. When the paper is in position the barb falls again into its normal position, preventing the paper from heing pushed or blown off the hook.

Convenient accessories of this sort add much to the comfort and despatch of office work.

PERSONAL MENTION.

MR. EDWARD P. THOMPSON, patent attorney and consulting electrician, is *not* dead—but alive, well and busy, spending a considerable part of his time in correcting the impression, which seems to have spread far and wide, that he was the E. P. Thompson reported killed in the recent railroad accident in Georgia.

THE BOSTON ELECTRIC CLUB.

Nearly 100 members of the Boston Electric Club sat down to a bountiful supper at the Thorndike last evening. After doing justice to the viands, several musical selections were rendered by a quartet from the Bell Telephone company. President Alexander then introduced Mr. Thomas D. Lockwood, chief of the electrical and patent department of the American Bell Telephone Company. who read an interesting paper, entitled "The Inevitable Anticipation" At its conclusion, President Alexander called upon Mr. Charles Dutton, secretary of the house committee of the New York Electric Club, who criticised humorously the paper of the evening. Mr. A. H. Chapman then took the chair and called upon Messrs. Cleverly, of Philadelphia, Pierce, of Boston, Wright, of Springfield, Rev. Mr. Cleveland, of Malden, Mr. W. J. Denver, and others.—*Boston Herald.*

THE PHILADELPHIA ELECTRICAL SOCIETY.

The committee on experiments and tests of the Philadelphia Electrical Society are engaged in making preliminary experiments, and obtaining data for their final tests upon the various electric protectors submitted to them by the inventors.

MANUFACTURING AND TRADE NOTES.

THE EAST RIVER ELECTRIC LIGHT CO. offer factory and storage room in New York city to manufacturers of electrical appliances. Their station, covering 10 city lots in East 24th street, is seven stories in height and substantially constructed. It is designed to make it a centre for electrical manufactures of all kinds, and 1,500 h. p. can be supplied day and night.

MESSRS. A. U. ALCOCK & CO., Melbourne, Australia, whose advertisement will be found in our columns, offer their services to intending American exhibitors at the forthcoming Melbourne Centennial Exhibition.

THE HILL CLUTCH WORKS, Cleveland, O., were awarded first prize, a bronze medal, by the American Institute of New York, for their exhibit at the annual fair last autumn.

THE WESTINGHOUSE ELECTRIC COMPANY have purchased the United States patents for Professor George Forbes' electric meter, and will manufacture them on an extensive scale for its own use.

THE CALLENDER INSULATING AND VULCANIZING CO. have sent out a new price list, under date of January, 1888. Their list embraces a large variety of electric conductors for many purposes. In addition to their Bitite wires and cables, they offer their Trinidad insulation for electric light conductors and other similar uses.

THE American Institute have awarded the medal of superiority to the Jerome Kidder Manufacturing Company, No. 820 Broadway, New York, for their exhibit of "Electro-Medical Apparatus Appliances and Instruments" at the fair of 1887. For fifteen consecutive years the Jerome Kidder machines have received the highest awards from the American Institute. Their large elaborately finished cabinet battery, unique in design, attracted much attention.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horsepower; **T.**, T rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scafe; *Sec.*, Arthur Kennedy; *Supt.*, J. J. Houghton; *Eng.*, Sam'l Drescher; 4 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 250 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Supt.*, G. Johnson; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; water-power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; 5 mi.; g. 4-8½; 25 and 56 lb.; overhead cond. SPRAGUE.

Denver, Col.—Denver Tramway Co.—*Pr.*, Rodney Curtis; *Sec.*, Wm. G. Evans; *Supt.*, Jno. C. Curtis; 4 mi.; g. 36; 16 and 18 lb.; 10 m. c.; sta. 125 h. p.; conduit cond. SHORT-NESMITH.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g. ——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE.
Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 8.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; 1 mi.; g. 5-2; 56 lb.; 2 m. c.; sta. 80 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1 c.; 1 m.; sta. —— h. p.; conduit cond. VAN DEPOELE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, Chas. D. Haines; *Sec.* F. H. Skeele; 1.5 mi.; g. 4-8½; 25 lb. T.; 2 m. c.; sta. 50 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Kansas City, Mo.—Kansas City Elect. Ry. Co.—*Pr.*, W. W. Kendall; *Sec. & Tr.*, Warren Watson; *Supt.* John C. Henry; 2 mi.; g. 4-8½; 70 lb.; 4 m. c.; sta. 80 h. p.; overhead cond. HENRY.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. VAN DEPOELE.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair Ry. Co.—*Pr.*, Theo. Evans; *Sec.*, J. W. Patterson; 2 mi.; g. 5-2½; 45 lb.; 5 c.; 5 m.; sta. 175 h. p.; overhead and conduit cond. DAFT.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. VAN DEPOELE.

Richmond, Va.—Union Pass. Ry. Co.—*Pr.*, J. T. Brown; *Sec.* and *Treas.*, J. F. Barry, *G. M.*, G. H. Burt; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 375 h. p.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. M. Waugh; 5.75 mi.; g. 4-8½; 30 lb.; 3c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Supt.* B. T. Killam; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 7 m. c.; sta. 360 h. p.; overhead cond. VAN DEPOELE.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond.; VAN DEPOELE.

Wichita, Kas.—Wich. Riverside & Suburban Ry. Co.—*Pr.*, J. O. Davidson; *Sec.*, N. G. Lee; 4 mi.; g. 6-8; 45 lb; 6 m. c.; sta. h. p.; overhead cond.
Wilmington, Del.—Front & Union St. Pass. Ry. Co.—*Pr.*, G. W. Bush; *Supt.* S. W. Drice; *Tr.*, E. T. Taylor; 1-3 mi.; g, 5-2; —— lb.; 2 m. c.; overhead cond. SPRAGUE.
Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.75 mi.; g. 3-6; 35 lb.; 1 c.; 2 m. c.: sta. 20 h. p.; overhead cond. VAN DEPOELE.
Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb. T; 1 m. c.; sta. 1,000 h. p.; overhead cond. BENTLEY-KNIGHT.

Constructing or Under Contract.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½: 45 lb.; 3 m. c.; 1 m.; sta —— h. p.; overhead cond. VAN DEPOELE.
Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—6 mi.; g. 4-8½; —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond. SPRAGUE.
Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.
Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown. VAN DEPOELE.
Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper. DAFT.
Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. VAN DEPOELE.
Elsinore, Cal.—Elsinore Lake Shore Elect. Ry. Co.—*Pr.*, D. G. Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.
Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; 6 m. c.; overhead cond. SPRAGUE.
Lakeside, O.—3 mi.; 2 c.; overhead cond.
Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi.; g. 4-8½; 56 lb.; 10 m. c.; storage bats.
Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.
New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*, E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.
New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.
Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.
Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.
Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.
Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, C. D. Haines; *Sec.* & *Tr.* F. H. Skeele; 4-5 mi.; g. 4-8½; 40 lb.; 6 m.; 6 c.;
Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.
St. Louis, Mo.—Lindell Ry. Co.—*Pr.* J. H. Maxon; *Sec.* and *Tr.* G. W. Baumhoff; —— mi.; g. 4-10; storage bats.
San Jose, Cal.—San Jose Motor Co.—*Pr.*, J. W. Rea.
Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.*, A. Frothingham; *G. M.*, B. F. Killam; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; overhead cond. VAN DEPOELE.
South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.
Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.
Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; 3.25 mi.; g. 4-8½; overhead cond. DAFT.
Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—7 mi.; g. 5-2; 50 lb.; 2 m. c.; overhead cond. SPRAGUE.
Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

Notes.

After many months spent in experimenting with and investigating motors for street railways, the Lindell Railroad Company, of St. Louis, using Washington avenue and other streets in that city, on Feb. 10 finally adopted electricity as the motive power for their road. The motor adopted is a combination of the Julien storage battery and the Brush machinery. One car has been in constant operation during the week and has given entire satisfaction, and the whole equipment of the road will be fitted out with the motor as soon as the necessary work can be done.—*N. Y. Times.*

IT is understood that the contract for the ten new electric cars which are being built for the Fourth Avenue line in this city provides for the delivery of so much power per car at a certain price, and this price is about forty per cent. below what the same power would cost furnished by horses. Julien storage batteries will be used, and it is expected that the ten cars will all be ready for use this spring.

THE new electric railway in Richmond, Va., which was equipped by the Sprague Electric Railway and Motor Company, of New York, is working successfully under very trying conditions, and is attracting favorable notice.

LEGAL NOTES.

UNITED STATES CIRCUIT COURT.—SOUTHERN DISTRICT OF NEW YORK.

The Holmes Electric Protective Company against *The Metropolitan Burglar Alarm Company.*

Patent to Holmes and Roome, No. 120,874 is for the change in the location of the protective electric lining from the inside to the outside of a safe. Question of patentability considered.

To find a new position for an old device is not patentable, unless a new result is produced.

The invention claimed in the patent sued on was described but not claimed, in a patent issued to the same patentees before the application for the patent sued on was filed. Held, that where a patent fully described an invention which could be claimed therein, and makes no reservation, and gives no warning to the public, a second patent granted upon an application filed some months afterwards, which claims simply and solely the invention thus made public is invalid. Cites and follows Mahn *vs.* Harwood.

Two years publication of an invention is not allowed an inventor before applying for a patent. An abandonment to the public cannot be recalled.

The addition of features, not found in the earlier patent, to the second patent could not bolster up the second patent as to the parts shown in the earlier patent. Guarantee Insurance Co. *vs.* Sellers.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From Feb. 21, to March 13, 1888 (inclusive).

Alarms and Signals:—*Conductor for Electrical Fire-Alarm Systems*, W. A. Barnes, 378,078. *Electro-Magnetic Bell*, J. and S. Wetzler, 378,124, Feb. 21. *Electric Ship Signal*, J. W. Dooley, 378,876. *Police, Fire and District Telegraph*, E. T. Gibson, 378,927. *Fire-Alarm Signal Box*, A. A. Smith, 378,983. *Burglar Alarm*, C. H. Wright, 379,144, March 6. *Fire-Alarm Signal-Box*, G. M. Stevens, 379,339. *Device for Returning Signals in District Telegraph Systems*, W. V. Lockwood, 379,404, March 13.

Conductors, Insulators, Supports and Systems:—*Telegraph Cable*, W. R. Patterson, 378,175, Feb. 21. *Test-Box for Underground Electric Wires or Cables*, R. S. Waring, 378,560. *Conduit for Electric Wires or Cables*, same, 378,561. *Underground Conduit for Electrical Conductors*, M. R. Muckle, Jr., 378,801. *Man-hole Chamber for Underground Electrical Conduits*, same, 378,802, Feb. 28. *Insulator*, L. M. Neal, 378,971, March 6. *Underground Conduit*, M. R. Muckle, Jr., 379,406. *Telegraph Wire*, W. Hewitt, 379,535, March 13.

Clocks:—*Machine for Regulating Time-Pieces*, W. B. Farrar, 379,511, March 13.

Distribution:—*System of Electrical Distribution by Secondary Batteries*, J. S. Sellon, 378,115. *Alternating Current Transformer*, R. Kennedy, 378,320. *Transformation and Distribution of Electric Energy*, same, 378,321, Feb. 21. *System of Electrical Distribution*. Conant & Latshaw, 378,452. *System of Electric Distribution*, T. Spencer, 378,787. *System of Electric Distribution*, same, 378,788, Feb. 28. *Continuous and Alternating Transformer*, F. Jehl, 379,073, March 6.

Dynamos and Motors:—*Core for Dynamo-Electric Machines*, W. C. Rechniewski, 378,375, Feb. 21. *Self-Exciting Alternate Current Electric Generator*, O. A. Moses, 378,456. *Regulator for Electric Generators*, W. S. Hill, 378,547, Feb. 28. *Magneto-Electric Machine*. O. P. Loomis, 378,892. *Dynamo-Electric Machine*, O. Urban and M. J. Wightman, 379,037, March 6. *Dynamo-Electric Machine*, L. C. Rice, 379,284. *Apparatus for Dressing off the Commutators of Dynamo-Electrical Machines*, D. J. Tittle, Jr., 379,344. *Regulation of Electric Motors*, D. Higham, 379,466 and 379,467, March 13.

Galvanic Batteries:—*Galvanic Battery*, H. Walter, 378,121; Walter & Marsh, 378,122, Feb. 21. *Battery Vessel*, J. Wiest, 378,484, Feb. 28. *Carbon Battery*, G. E. Terrell, 378,943. *Depolarizing Compound*, A. F. W. Partz, 379,180, March 6. *Non-Polarizing Constant-Current Battery*, F. J. Crouch, 379,372. *Primary Electric Battery*, H. Woodward, 379,551 and 379,552, March 13.

Ignition:—*Electric Gas-Lighting Apparatus*, C. W. Holtzer, 378,677, Feb. 28. *Electric Gas-Lighter and Extinguisher*, G. L. Hogan, 379,396, March 13.

Lamps and Appurtenances:—*Manufacture of Incandescent Electric Lights*, T. Mace, 378,258. *Incandescent Electric-Lamp Fixture*, H. M. Doubleday, 378,358, Feb. 21. *Arc Light*, L. N. P. Poland, 378,616. *Air Pump*, H. J. Doerr, 378,666. *Double-Arc Lamp*, Wightman and Rasmussen, 378,818, Feb. 28. *Incandescent Lamp Socket*, F. Thone, 379,255, March 13.

Metallurgical:—*Working Metals by Electricity*, N. De Bernados, 379,453, March 13.

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THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS, JR.

PUBLISHED MONTHLY BY

THE ELECTRICAL PUBLISHING CO.,

11 Wall Street, New York city.

TERMS OF SUBSCRIPTION.

United States and Canada, per annum,	$3.00
Four or more Copies, in Clubs (each) "	2.50
One Copy, Four Months,	1.00
Great Britain and other Foreign Countries within the Postal Union "	4.00
Single Copies, -	.30

[*Entered at the Post Office at New York, N. Y., as second class mail matter.*]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of the* ELECTRICAL PUBLISHING CO. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

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VOL. VII. NEW YORK, MAY, 1888. No. 77.

NOTICE OF REMOVAL.

THE ELECTRICAL PUBLISHING CO., publishers of the ELECTRICAL ENGINEER—remove their offices May 1, from 115 Nassau street to 11 WALL STREET, New York.

SPECIAL NOTICE.—To afford an opportunity to become acquainted with **THE ELECTRICAL ENGINEER,** *the publishers will send it to any new address for* THREE MONTHS *for* FIFTY CENTS.

The publishers have pleasure in announcing that by arrangement with the WESTERN ELECTRICIAN *of Chicago, they are enabled to offer that able Western exponent of Electricity together with the* **ELECTRICAL ENGINEER,** *for one year to new subscribers for* $5.00. *To those of our present subscribers who desire it we will supply the* WESTERN ELECTRICIAN *one year for* $2.50

THE PATENT REFORM BILLS.

WE print elsewhere in this issue the bills for amending some features of the organization of the patent system prepared by the legal committee of the National Electric Light Association, and now before the House Committee on Patents. These bills, as our readers are already aware, are directed, one to the creation of a Court of Patent Appeals, and the other to increasing the permanency and efficiency of the office of Commissioner of Patents. A third bill, known as the Atkinson bill, dealing with the present vexatious limitation of United States patents by foreign patents of prior issue, was found before Congress by the committee of the Association, who will favor its passage with some changes of detail, which, we believe, have not yet been perfected.

These measures, substantially in their present form, have been presented in the columns of the ELECTRICAL ENGINEER, and other electrical journals, on several occasions during the past year, together with the very able arguments in their support of Mr. Arthur Steuart, chairman of the legal committee of the Electric Light Association, and others. They receive cordial support on all sides among men who, through their business or profession, are brought into close relations with the patent system. Among other endorsements is that of the Chicago Electric Club, which has adopted a series of resolutions commending the bills and urging their adoption. We are informed that the Court of Patent Appeals bill has been most favorably commented upon by several of the Justices of the United States Supreme Court, including the late Chief-Justice. So far as we have learned, no objections or unfavorable criticisms of either measure have been put forward. That the Court bill would greatly simplify and expedite patent litigation seems to be generally conceded ; and there can hardly be less doubt of the advantage to be derived from the passage of the Commissioner's Office bill. By increasing the dignity and importance of the office and adding to its stability, it may fairly be expected to bring about a more settled condition of the rules and regulations under which patents are granted.

It is to be hoped that the authors of these measures will continue to receive hearty support, and that all who appreciate their scope and bearing will take pains to communicate with the legal committee of the National Electric Light Association, 213 East German street, Baltimore.

THE INSTITUTE OF ELECTRICAL ENGINEERS.

THE annual meeting of the Institute for the election of officers, presentation of reports and miscellaneous business, will be held at 127 East 23d street, New York (House of the American Society of Civil Engineers), May 15th. The general meeting for the reading and discussions of papers will be held at the same place on May 16th. The papers already announced are as follows :—

"Some Old and New Applications of Alternating Currents," by Lieut. F. Jarvis Patten, U. S. A. "On Compensated Resistance Standards" and "On Professor Moler's 'Swinging Arm' Galvanometer" by Professor Edward L. Nichols, of Cornell University. Papers on "Subterranean Electrical Systems," by Professor George W. Plympton, and on "The Possibilities and Limitations of Chemical Generators of Electricity," by Francis B. Crocker, will also be presented. Papers have been promised by foreign members, the subjects of which can not be given at present.

The work of the Institute has steadily grown in interest and value. The published transactions of the annual meetings and of the monthly meetings of the last two seasons mark a very satisfactory and gratifying advance. The increase in membership since the last annual meeting has proved far in excess of the expectations of the council, and it still goes on.

As might be expected of an American technical society, the work of the Institute, in its papers and discussions, has been of a noticeably practical kind; often directly and entirely so, and nearly always, when partly or wholly theoretical, closely related to practical work. Of work "in the air" leading no-whither, there has, happily, been little if any.

The forthcoming general meeting promises to succeed worthily the May meeting of last year.

THE TELEPHONE PATENTS AGAIN SUSTAINED.

The suit which was brought by the American Bell Telephone Company against the Southern Telephone Company, last fall, to restrain the latter company from infringing the Bell patents, was decided by Judge Brewer, at Little Rock, Ark., on April 21, in favor of the complainant. A writ of injunction was immediately served upon the officers of the Southern company in Little Rock, where it has about 500 instruments in use. The enterprise was owned by Little Rock parties, and the plant is said to have cost about $53,000. As the decision is, in some respects, an important one, we have printed it in full in our present issue.

It is rather unfortunate that the gentleman "just returned after a two years' sojourn" in India, where, he believes, the telephone "dates back fully 2,000 years," did not get here in time to tell us all about it before the United States Supreme Court decided that Professor Bell was the real inventor.

A column and-a-half is given by a weekly electrical contemporary to an account of what Mr. Amesbury, with "an English officer named Harrington," saw and heard of ancient telephones in India. It appears that only "high caste" natives use telephones, and not only confine their use to the service of their temples, but have successfully kept their existence a secret until very recently. Besides telephones, they have real subways; underground conductors in wooden conduits being found by Mr. Amesbury and "Harrington" connecting temples several miles apart. The conducting wire was of some mysterious metal, the nature of which the observers were unable to determine, though they were quite sure it "was neither steel, copper nor brass." The telephones examined were found to have "been in use for thirty years. The priests were very old men, and they remembered that the line of communication had been renewed only once during their incumbency. They showed us the remains of worm-eaten transmitters and wooden conduits that must have been hundreds of years old." No mildewed remains of a subway commission are mentioned among the finds. The narrator further says: "In every part of India and in Burmah this system of secret communication exists, although hundreds of travelers have never suspected it"

We trust that Mr. Amesbury and his friend "Harrington" were not piloted around among the Indian temples by Madame Blavatzky and Colonel Olcutt. If, as we strongly suspect, the whole yarn be a little joke by some wag on the staff of our clever and often amusing contemporary, we trust its publication has raised no false hopes of re-opening the appealed telephone cases, and throwing the telephone open to the public.

That fatal or serious accidents from electric light circuits are mostly if not wholly preventable is perfectly certain. They still occur, though not frequently. Carelessness on the part of the victims is sometimes the cause, but too often it is to be found in the absence of proper precautions and safe-guards in the construction and management of central stations and circuits. The personal equation of carefulness on the part of linemen and lampmen should be practically eliminated. Wherever sure protection can be provided, it should not be permissible to trust to the cautiousness of employés. These remarks are suggested by the case of Ameron Kratz, a lamp-trimmer, who was permanently disabled by a shock received while in the performances of his duties on a high tower at Detroit. It is alleged that he received the shock from a wire which he had been told was "dead." He brought suit against the local electric light company for $25,000 damages. The jury awarded him $10,000. The company pleaded Kratz's negligence in their defense. We have seen none of the testimony in the case, but whatever the merits may be between Kratz and the company, the verdict suggests an additional incentive to manufacturing and operating electric light companies not to stop short in the very general improvement that is going on in the construction and operation of plants until they are quite sure they have exhausted all known means of ensuring immunity from death or bodily injury to all who handle or use electric lights.

Under the title, "Gilbert's Fables," Mr. T. Commerford Martin contributes to the *North American Review*, for April, a striking and very interesting article, bringing together an enumeration of the results reached in the leading electrical arts and industries, from the telegraph, now but 50 years old, to electric light and power, the products of the last 10 years. The telephone dates but 12 years back. The aggregate of capital and labor already employed in the manufacture and service of the machinery and apparatus of these new electric arts, as indicated in Mr. Martin's paper, is almost surprising, even to those acquainted with these applications of electric science. Mr. Martin happily introduces his subject by quoting Lord Bacon's somewhat contemptuous allusion to Dr. Gilbert as "telling so many fables" in his now famous work, "De Magnete," and throughout the article intersperses many apt allusions and illustrations, drawn from his wide and generous acquaintance with general literature.

Those who disapprove the Board of Electrical Control and all its doings, may take some solace in the prospect of some more fun from the Mayor and Mr. Gibbens. Mr. Hewitt promptly resumed his nagging of Mr. Gibbens at the first meeting of the board this season, while that energetic and vivacious young gentleman was no less ready to re-open hostilities. Whatever we may get in the way of conduits and conductors, the Mayor's incisive questions and caustic comments, together with Mr. Gibbens's bumptious alertness, are quite sure to supply some diversion for the long summer months. Meanwhile, might it not be prudent for Mr. Gibbens to keep a sharp eye out for bears on his way home nights?

WHILE in this country the Knights of Labor and other workingmen's organizations are petitioning Congress for government telegraphs, the publication in England of the Postmaster-General's report, showing the receipts and expenditure of the telegraph service of Great Britain since its acquisition by the state, is causing popular discontent with the series of annual deficits which have to come out of the tax payers.

There is something absurd in the attitude of the Knights of Labor on this question. Probably more than nine-tenths of the telegraphing in the United States is done by people who pay in the aggregate less than one-tenth of the taxes, and who constitute a still smaller fraction of the population—that is to say, by those engaged in conducting the manufacturing, commerce and journalism of the country. A government telegraph service at rates materially less than those now prevailing, must inevitably result in losses which would have to be made good from taxes. Do the workers for wages really want to help pay for the telegrams of the merchants, manufacturers, bankers and editors of the country? Or has their movement its real origin in a fancy that it will in some way strike at the pocket-books of Mr. Jay Gould and other capitalists?

THE development of electric lighting interests in England, which has been so greatly retarded by unfavorable legislation, may be to some extent stimulated by the passage of the County Government Bill before Parliament, which would transfer the present onerous control of electric lighting franchise from the Board of Trade to local authorities. Commenting on this subject in a recent number, *The Electrician*, of London, says:—

If the County Government Bill should pass into law in the shape now before the House, the powers at present exercised by the Board of Trade in connection with the granting of provisional orders under the Electric Lighting Act, will be transferred to the new County Councils. It may fairly be presumed that, on the whole, such a change would operate favorably upon the development of electric lighting. Time will certainly be saved, legal expenses would probably be diminished, and a wider local interest would be aroused in the undertaking.

USEFUL knowledge, immediately applicable to their work, is always gratefully received by electricians. The following is from the "Practical Information" column of an esteemed contemporary:—

Galvanic Cell.—The cell contains zinc in an alkali. The polarization is prevented, not by oxide of copper, but by oxide of mercury, which, by dissolving in the alkaline solution, amalgamates the zinc. In order to increase the surface it may be mixed with iron shavings.

IN the suit of the Consolidated Electric Light Co. against the McKeesport Electric Light Co. (Edison system) for alleged infringement of the Sawyer-Man filament patent, Judge Acheson, of the United States Court, Western District of Pennsylvania, has dismissed the demurrer of defendants, and ordered the filing of an answer to the complaint. The issue of this suit may be expected to clear up much uncertainty and perplexity as to the relations of incandescent electric light patents, and the respective rights of several companies.

THE Underground Conduit franchise granted by the Boston board of aldermen, described in our Boston correspondence, was promptly vetoed by Mayor O'Brien—on the opinion of the Corporation Counsel that it was illegal.

OBSERVATIONS.

THE observer has been reading the Rules and Requirements of the New England Insurance Exchange, adopted March 1, 1888. They are 73 in number, mostly excellent, and represent the long stride which practical men have taken towards a working knowledge of the force which we term electricity.

The rules as a whole are so good, that only four of them stand out from the others either as "bright particular stars," or as "occultations."

These are respectively the 20th, 34th, 61st and 70th. The first and third of this quartette, are noticeable chiefly for the evidence they afford that the incisive arguments of Brother I. N. Miller, are returning after many days; *underwriter's wire* being specified as something which must not be used in *damp* places; where ammonia vapors prevail, or for pendants. The covering of the said wire is still, however, frequently dignified by the term "insulation."

The 34th rule is the problem of the list. Rosin as a flux is prohibited, and a preference for an acid solution not stronger than 10 per cent. is manifested. The writer has several times been asked the reason of this rule, but he would prefer to undertake the solution of "The Lady or the Tiger," or the "Discourager of Hesitancy."

The expert who evolved the rule in question, will doubtless explain that the average man cannot make a good job of a joint when he uses rosin as a flux, or at all events doesn't; to which the rejoinder might fairly be made that such a man should not be allowed to make joints or splices at all, for he will surely forget to wash off the superfluous acid. It would be better to stick to the resin.

As to rule 70; the test required by it may answer very well, when the circuit to be tested is very short, or has but few branches; but it would hardly be trustworthy on a very long circuit; as a magneto machine will ring its own bell on an open circuit with an electrostatic capacity which is quite low.

* * *

THE daily press is always interesting when it touches on scientific subjects; it is also frequently amusing and occasionally instructive. When a subject is on the *tapis* which in addition to its scientific interest involves questions of a legal character, the boldness with which it is tackled by the average scribe, excites in our breasts an involuntary admiration, of an intensity to which we have been strangers, since the time when in the days of boyhood we were wont to peruse with thrilling awe, the final 11 pages of our school dictionaries, wherein was recited the story of the bearding by Theseus of the Minotaur in his lair.

These observations are suggested by the comments of the secular and religious daily and weekly papers upon the lately delivered telephone decision.

Space will not permit a report of even the most striking here; but one or two deserve and require at least passing comment.

One statement which appeared in a number of papers—and which started out as a Washington despatch is the following:

"The Supreme Court has sustained the broad fifth claim of the *company* * * * which seems to make it impossible now for any person to secure a valid patent for a speaking telephone," then the author of the despatch exhibits his knowledge of patent law—continuing, "It would seem, therefore, that American ingenuity must direct itself *for the remainder of the 14 years of the original patent to some other channel than in attempting to invent improvements in the method of transmitting* AUDIBLE *speech by electric wires.*"

Another newspaper Solon—(this time the Boston *Watchman*, a religious denominational organ) comes out with the following statement of fact. "Not only is priority of invention declared, but exclusiveness also. One of the cases, that of Amos E. Dolbear, related to an invention distinct from that of Alex. G. Bell, it being a magnet telephone, with a magnet, coil, and armature, while the Bell invention operates by static attraction, by means of metal plates opposed to each other."

Perhaps, however, the funniest pronunciamento is that of a Rochester, N. Y., newspaper, which says that "there is still hope

for the public. None of the telephone cases on which the court has delivered judgment, presented the *Reis* defense, which was, therefore, not considered. The government case now to be brought, will for the first time introduce the publications regarding the Reis telephone, which will furnish evidence absolutely irresistable."

• • •

WHAT has "current-jelly" to do with electricity? Until recently, nothing. But from this time, henceforth and forever, that sublime accompaniment of broiled quail and roast duck is to be associated with voltaic batteries—*vide* United States patent issued January 31, 1888, for a chromic acid battery. The inventor first (so he says in his specification) dissolves chromic acid in water, and then adds sulphuric acid and stirs; mineral wool or asbestos is then gradually added, and the mixture now reaches its maximum heat. As it again grows cool, it is changed into a jellied mass.

The patentee, with profound knowledge of human nature, then goes on to surround his battery with a captivating interest calculated to rouse curiosity and desire in the public to try his battery (after which they will, of course, use no other) by saying that this jelly he has called "electric current jelly."

• • •

THE electric light companies and lighting apparatus manufacturers of New England, have begun a good work in the organization of "The New England Electric Exchange."

The proposition to issue licenses to properly qualified persons, as also the gradation of licenses, would seem to be admirably adapted for the improvement of construction, for the prevention of casualties, and for elevating all classes of men connected with electric lighting. Now let the exchange continue in the way it has begun, by seeing to it, that the examiners appointed are men regarding whose opinion no doubt can arise, and who are thoroughly practical themselves. The value of a license, will in no slight degree depend upon the known qualifications of the examiners or licensors.

• • •

It appears from the public prints that the Boston board of aldermen has voted, after several hearings, to grant certain petitioners an ordinance conferring the exclusive right for a term of years to lay and maintain conduits for electric wires in the streets of that city.

The various electric companies doing business there do not (if appearances may be trusted) seem to relish the idea.

Nor do the daily papers take kindly to the notion of an exclusive license for this privilege. Always excepting the *Herald*.

The last mentioned paper has been interviewing persons who are supposed to have opinions on such matters; and it is, in fact, a published account of one of these interviews that attracted the attention of the observer. A practical electrician who has charge of a large electric light plant, but who desired that his name should not be used, said:—"The talk about not being able to carry the electric light, and telephone and telegraph wires in the same conduit is all moonshine. *Suitably insulated, there would be no danger of induction.*"

It is a pity the practical electrician would not consent to the publication of his name.

• • •

A MEMOIR of Fleeming Jenkin, the well-known electrician has been written by that most versatile author, Robert Louis Stevenson. All electricians will do well to add this to their libraries. Very little is said in it about electricity, but by its perusal one finds that Jenkin, though one of the busiest of men, and though filled with enthusiasm for his work, was good as well as great; was permeated with a wide humanity and an overflowing charity for all; and was, withal, of a homelike and home-loving disposition. Books like the memoir of Jenkin, and the biography of Clerk Maxwell are invaluable, as leading us to a better understanding of the men, and consequently of their technical works. Mr. Stevenson is to be congratulated upon his success as a biographer, and has shown that he can shine with equal brilliancy in his new role, as in that of a novelist, poet, or essayist.

ARTICLES.

DATA FOR WINDING COILS.

BY SCHUYLER S. WHEELER.

THE spaces occupied by insulated magnet wire of the various sizes when wound in solid coils, including the average irregularity actually found in practice, are given in the following table in the form in which they can be used most conveniently in calculations, together with all the resultant data of weight, capacity of coil per inch, &c., that are required in designing electrical machinery.

To determine the size of wire which may be used in winding a coil, it is generally necessary to take the diameter of any wire from the common wire tables, add the estimated thickness of the insulation, add a trifle more to cover the occasional failure to wind the convolutions close together, and with this estimated size as a basis, compute the number of turns which can be wound in a given coil, making allowance also for the gain of space caused by the turns of wire of each outer layer falling into the spaces between the turns of the under layers. And if the number of turns of the coil or its resistance and other elements are not satisfactory, it is necessary to repeat the same operation with another size of wire.

The laying out of coils is of constant recurrence; and these dimensions, namely, the spaces required for wires, have always been so unsettled, that it occurred to the writer to try to reduce the drudgery of electrical engineering by settling them once for all by test; putting the results in shape for convenient use, and publishing them after the manner of the specific gravities of substances. The table was made according to this plan, and gives all of the dimensions and data of single cotton covered magnet wire when closely wound in a coil, not as estimated but as they *are*. That is, the figures given are each the average of several coils actually wound, and they therefore include what would be called allowances for probable error when guessing the thickness of the insulated wire. The figures or constants given, having been derived from coils actually wound and reduced to the basis of an inch, will give exact results within extremely close limits when multiplied up to the dimensions of any coil. For the purpose of ascertaining very accurately the number of turns of wire to the inch down to one decimal place, a great many large coils, including coils wound with nearly every size of wire from No. 4 to No. 30, were very carefully measured both in length and depth of wire, and the number of layers and turns of wire counted. In each case several observations were made by different men on different coils of the same size wire, and the results averaged. The number of turns was then divided by the inches of length, giving the number of turns per inch of length of bobbin. These figures are in the first column of the table. The number of layers on the trial bobbins was then divided by the depth of the wire on the spools, carefully determined, giving the number of layers per inch, and these results were then averaged. It was necessary to reduce these to layers per inch before averaging, because the coils under observation were wound to different thicknesses. These values make the second column of figures in the table. Both sets have been carried out to the second decimal place, so that when multiplied by a number of inches in designing a large coil the error will fall below one convolution if possible.

The third column represents the number of turns of wire to the square inch of cross-section of coil, or, in other words, the number of turns which could be got on a spool one inch long and one inch deep on all sides. This was obtained by simply multiplying together the two preceding values, namely the number of turns per inch in the layer, and the number of layers per inch of depth of coil. The accuracy of the three columns was then checked by measuring the square inches of cross-section of the coils on which the ob-

servations were made, and multiplying in the turns per square inch according to our third column to see if it agreed with the total number of turns on the observed coils.

To illustrate the use of these figures let us find what size of wire we must wind on a magnet, whose winding space is three inches long and one inch deep, to get one thousand turns on the magnet. There are three square inches of space in the section of the spool (on one side) therefore each square inch must take 333 turns of wire. Looking in the table of turns to the square inch we find No. 16 nearest, giving 324 turns, therefore No. 16 wire wound on the magnet would give 972 turns in the given space, while No. 17 would give three times 378 or 1134 turns. Of course it is understood that the steps of increase of diameter between consecutive standard sizes of wires produce corresponding abrupt steps in all the data of the table, and that this cannot be avoided without special intermediate sizes.

To illustrate the use of these values, let us find what size of wire we must wind on a magnet, one inch in diameter, whose winding space is three inches long and one inch deep on each side, in order to get 20 ohms resistance. Calculating the space for wire in cubic inches, as in the ordinary way of determining the volume of hollow cylinders, by subtracting the volume of the central inner cylinder formed by the magnet itself, from the total volume of the spool, we find that there are 18.8 cubic inches of space for wire on the spool, therefore each cubic inch must have $\frac{20}{18.8} = 1.06$ ohms. Looking in the column of ohms to the cubic inch we find that No. 21 is the nearest size giving .98 ohm. Multiplying this by 18.8—the cubic inches of space—we find just what resistance this wire will give when the coil is wound.

In the same way if we have a helix of 500. ohms resistance, and we wish to rewind it to have 400. ohms resistance, without figuring its cubic inches of wire space, we simply

TABLE OF SPACES OCCUPIED BY WIRES OF DIFFERENT SIZES, WITH SINGLE COTTON INSULATION, TOGETHER WITH DATA OF THE COPPER.

COMPILED BY SCHUYLER S. WHEELER.

Data of the Insulated Wire.										Properties of the Copper Conductor†				
No. American or B. & S. Gauge.	Turns to the Inch.	Layers to the Inch.	Turns to the Sq. Inch.	Feet per Cub. Inch.	Ohms per Cub. Inch.	Lbs. per Cub. Inch.	Feet per Lb.	No.	Per Cent. of Solid Copper in any Volume of Winding.	No. American or B. & S. Gauge.	Diameter Mils.	Circular mils (d^2) 1 mil=.001 in.	R. Ohms per 1000 feet.	Feet per Lb.
1										1				
2										2				
3										3				
4	4.5	4.87	22.1	1.84	.0004576	.24	7.	4	.75	4	204.310	41742.00	.24869	7.93
5	5.09	5.82	29.6	2.46	.0007738	.24	9.	5	.74	5	181.940	33102.00	.31361	10.00
6	5.66	6.41	36.3	3.02	.0011963	.24	11.5	6	.74	6	162.020	26250.50	.39546	12.61
7	6.2	7.3	45.3	3.77	.001780	.24	14.	7	.73	7	144.280	20816.00	.49871	15.90
8	7.05	8.	56.5	4.7	.0029654	.24	17.5	8	.73	8	128.490	16509.00	.62881	20.05
9	7.66	8.42	64.5	5.37	.0042574	.24	22.	9	.73	9	114.430	13094.00	.79281	25.28
10	8.54	9.6	82.	6.83	.00683	.238	27.	10	.72	10	101.890	10381.00	1.	31.38
11 *	9.7	11.	116.7	9.72	.012254	.236	34.	11	.72	11	90.742	8234.00	1.2607	40.20
12	11.2	12.8	143.4	11.95	.0150654	.233	42.	12	.71	12	80.808	6529.90	1.5898	50.69
13 *	12.	14.	168.	14.	.03627	.23	55.	13	.71	13	71.961	5178.40	2.0047	63.91
14	13.	15.4	200.	16.66	.0431627	.227	68.	14	.70	14	64.084	4106.80	2.5908	80.59
15	15.37	17.9	275.5	22.96	.071520	.224	87.	15	.68	15	57.068	3256.7	3.1150	101.63
16	16.74	19.4	324.7	27.06	.108757	.22	110.	16	.64	16	50.820	2582.9	4.0191	128.14
17	17.74	21.33	378.4	31.53	.15980	.217	140.	17	.62	17	45.257	2048.2	5.0683	161.59
18 *	19.5	23.	448.5	37.38	.2389	.19	175.	18	.61	18	40.303	1624.3	6.3911	203.76
19	22.77	24.9	567.	47.25	.39165	.185	220.	19	.60	19	35.390	1252.4	8.2889	264.26
20	25.7	29.7	763.3	63.60	.6464	.184	280.	20	.58	20	31.961	1021.5	10.163	324.00
21	28.3	32.5	920.	76.6	.98163	.182	360.	21	.57	21	28.462	810.10	12.815	408.56
22	31.	36.	1116.	93.	1.502	.18	450.	22	.55	22	25.347	642.70	16.152	515.15
23	34.4	40.36	1390.3	115.86	2.36	.178	560.	23	.52	23	22.571	509.45	20.377	649.66
24	36.9	44.6	1649.	137.4	3.53	.168	715.	24	.45	24	20.100	404.01	25.695	819.21
25	38.	47.	1790.	149.2	4.734	.145	910.	25	.43	25	17.900	320.40	32.400	1032.96
26 *	42.	50.5	2100.	170.	7.	.14	1165.	26	.41	26	15.940	254.01	40.868	1302.61
27 *	48.	55.5	2600.	210.	10.5	.135	1445.	27	.40	27	14.195	201.50	51.519	1642.55
28	53.28	61.1	3256.	271.3	17.63	.13	1810.	28	.39	28	12.641	159.79	64.966	2071.22
29 *	59.	68.	4000.	335.	27.	.125	2280.	29		29	11.257	126.72	81.921	2611.82
30	63.26	76.8	4860.	405.	41.84	.121	2805.	30	.38	30	10.025	100.5	103.30	3293.97
31										31	8.928	79.71	127.27	4152.22
32										32	7.950	63.20	164.26	5236.66
33										33	7.080	50.13	207.08	6602.71
34										34	6.304	39 74	261.23	8328.30
35										35	5.614	31.52	329.35	10501.35
36										36	5.000	25.000	415.24	13238.83

* Estimated.

† Calculated on the basis of Dr. Matthiessen's standard, viz.: 1 mile of pure copper wire of 1-16 in. diam. equals 13.59 ohms at 15.5° C. or 59.9° Fahr.

The next column gives the feet of wire in a coil, per cubic inch of spool space. This is obtained by dividing the figures in the last column by twelve, since if there are one hundred turns or strands in a square inch of spool space, there are one hundred inches of wire in a cubic inch of the same winding. While the preceding column of turns per square inch settles the magnetizing capacity of a coil, this last column is of equal importance because it is the key to both the weight and the resistance of any coil of any size of wire.

The next column gives the resistance per cubic inch of wound wire, and enables us to compare instantly the respective resistances of spools full of different sized wires, or to predetermine the resistance of a coil. It is obtained by multiplying the preceding column, or the feet per cubic inch, by the ohms per foot of the wire.

look in the column of ohms per cubic inch of wound coil and see what wire has to each cubic inch, four-fifths of the resistance of the wire already on the helix. Then when wound with that wire the coil will have four-fifths of the resistance it had before, because the cubic inches of wire will be the same in both cases, and the specific resistance giving capacity of the insulated wires when coiled are in the ratio of four to five per unit of volume.

The next column gives the weight per cubic inch. This item is necessary to determine the weight of wire which will be required for a given coil. The figures were obtained by weighing the wire used on the observed coils and dividing by the cubic inches of their respective spaces, and was corroborated at some points by multiplying the feet of wire per cubic inch by the feet per pound of wire, weighed and measured.

The last column under insulated wires gives the feet of wire of each size per pound, as stated in the catalogues of the wire manufacturers, and as tested.

To these are added some of the more important columns from the ordinary wire tables in order that all requisite data of the conductor itself, carrying capacity, resistance, etc., may be obtained for any calculation without keeping another table at hand. These values are well known and explain themselves.

There is also added a column giving the proportion of solid copper in any given volume of winding. This is obtained by multiplying the number of turns of wire to the square inch, by the circular mils or area of section of the bare wire, which gives the amount of metal which can be got into each square inch of space, or the percentage of metal in any coil. This is important as showing the efficiency of the winding or the inefficiency of the insulation. It is be noticed that a bobbin wound with No. 4 wire contains about twice as much metal as the same bobbin wound with No. 30. This shows why the weight per coil per cubic inch (as given in the column of weight per cubic inch), decreases with decrease in the size of wire.

The value of all of these figures is that they are as accurate as the variations of wire and of the work of different men in winding will permit, being the average of a great many helices which have come under the writer's observation in the regular course of manufacture, and which are therefore more likely to be of the average quality, and free from the favor of special care. Being all reduced to a standard of one inch the data is in shape to be applied directly to any helix or spool large or small, by simply multiplying it by the corresponding dimensions of the helix in inches.

Three quarters of the calculating—all that is dependent upon the wire—is done permanently, and preserved ready to be "mixed for use." There remains nothing but to fit the data to the spool,—to multiply the unit amount per inch, square inch, or cubic inch, as the case may be, by the size of the coil.

The simplest use of the table is to ascertain the correct wire for a coil wound on trial and found to be wrong. For example, if it was wound with No. 14 wire, but is then found to require twice as many turns, it is easy to glance down the column of turns to the square inch and see what wire makes twice as many turns in a square inch as does No. 14. It falls between No. 17 and No. 18. These sizes of wire will therefore give nearest to double the number of turns when wound on the coil. Similarly if the resistance of the coil is to be made seventy-five per cent. greater we can look in the column of resistances to the cubic inch, for the size that will give seventy-five per cent. more resistance than No. 14. It is found to be No. 15.

If we have a spool of a fixed size and must put a thousand turns on it, we measure the section of the winding space on one side and find how many turns we must wind in each square inch of that section, by dividing the inches of cross-section of spool space into the thousand turns, and then taking this quotient or the required number of turns to each square inch, look for that number of turns to the square inch in the table. If, however, the wire must be of a certain size to carry the current we are limited on the size of wire, but we may read the number of turns to the square inch for that wire and, multiplying by the inches of section of the coil, we find the number of turns we can have in the given coil with this wire.

The column of weight of wire per cubic inch of coil gives us the means of telling at once what the weight of any coil will be when wound with any size of wire, or, what is the same thing, what will be its cost for copper. The weight of any helix may be predetermined by multiplying the cubic inches of wire space on the spool by the weight per cubic inch of the wire that is to be used.

Perhaps a good way of showing the usefulness of the table is by calling attention to the fact that the figures give the respective properties, resistance, weight, turns, etc., of each size of wire, per unit of space, or "specifically," so that they are all on a common basis for comparison; and that it gives all of these as they are after being affected by the insulation, average goodness of coiling, etc., etc., including all of the defects that are met with in regular practice, so that calculations based upon the figures will be as near as possible to the results as found in the coil when it is made.

As all the figures in each of the columns refer to a common unit amount of wire space, they indicate upon comparison the exact rate at which the capacity of a helix will change in each respect, as the wire on it is changed from one size to another. If the wire on a helix is changed from one size to another, the helix will be changed in each respect exactly in the ratios of the figures opposite the two sizes of wire in question. Exact correctness and agreement of figures based upon such variable quantities as unspun cotton, crooked wires, and varying tightness of winding, is not to be expected, but reasonable accuracy is of great practical value, and is attained in the table. In fact it is surprising how closely alike quantities of coils of each size of wire turn out in the long run. It was thought at first from unsatisfactory experiences in trying to estimate turns for coils, that the irregularities were so variable that a satisfactory table could not be constructed, but it was found that in practice the coils of each size run about the same every time, notwithstanding the use of wire manufactured in different places, winding by different men, and the use of different qualities of insulation. The conclusion was that poor success in estimating the turns that can be got on a bobbin, by guessing at the way that the wire will probably wind, is not so much due to the unreliability of the wire as to the impossibility of telling just how much the turns will fit into each other, how much the insulation will compress, etc., etc., without trying it. The facts that insulation is usually rejected if it varies beyond certain limits as unfit for use, and that a thick insulation will compress more than a thin one in winding, account partially for the regularity of windings. Slight variations from the standard in the sizes of wires is a more serious cause of error, as the wire is not compressible. In using the tables it will be necessary to make allowance for this when occurring, as the tests were made upon wires of standard size.

The writer will be grateful for correction of any material error in the table, or any suggestion to increase its usefulness.

DISCUSSION OF THE PRECISION OF MEASUREMENTS.[1]

BY SILAS W. HOLMAN, S. B.

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(Continued from page 49).

Significant figures. By a significant figure is meant any digit other than zero. By places of significant figures will be meant places which properly may contain significant figures; *i. e.*, places other than those where zeros are used simply to enable the position of the units place to be indicated, as when zeros are prefixed to significant figures in a decimal fraction, or suffixed to them when significant figures are not known for all the places down to the units. The decimal point is simply a conventional sign to indicate the units place, and its position in no way indicates or affects the number of significant figures or the fractional accuracy of a result. Thus, for instance, to say that a distance was measured to 0.1 mm. gives no indication of the number of places or the fractional precision, unless we know what the whole distance was. Suppose that this was about two meters. Then the frac-

tional precision would be the same; viz., one in 20,000, whether written as 2 m., or 20 dm., or 2000. mm., or 0.002 kilom. And in computations involving this distance, six places of significant figures would be retained, independent of what unit it was originally expressed in. Rules for the rejection or retention of places of significant figures in data and computations may be deduced from the principles already presented. They are important for the avoidance, on the one hand, of waste labor and a delusive or ludicrous display of figures, and on the other to insure to the computed result all the accuracy to which it is entitled by the data.

Let M be an original observed quantity and δ its average deviation. Let that place of figures in M which corresponds to the second place of significant figures in δ be called the rth place. The average deviation by its derivation denotes that M is uncertain on the average by an amount δ. For instance, if $\delta = 0.034$, then M on the average is uncertain by three units in the $(r-1)$th pace; *i. e.*, in the place corresponding to the first significant figure in the average deviation, and in the rth place by 34 units. In general, the first significant figure in the δ may be anything from 1 to 9, as the case may be; hence in general M is uncertain by 1 to 9 units in the $(r-1)$th place, and by 10 to 90 (or strictly 10 to 99) in the rth place. Thus the digit in the $(r-1)$th place in M is always somewhat uncertain, and that in the rth place is very uncertain. It is useless, therefore, to retain significant figures in M beyond the rth place, and when the δ is large even this place is of little use. Also two places of significant figures in any δ are all that are of any use, since the only service of the δ is as an index of the precision of its quantity M,—or, stated in another way, because, as may be seen by inspection, the second and subsequent places of significant figure in any δ are very uncertain.

Thus anything which affects a quantity M beyond its rth place is wholly negligible, and in all ordinary work any effect less than $0.1\ \delta$ is sufficiently small to be neglected, for M is of itself uncertain on the average by ten times this amount. Let us adopt, then, as the basis of rules for significant figures, the condition that the accumulated error arising from the rejected places of figures must not at any stage of the computation exceed that corresponding to $\frac{1}{10} \cdot \frac{\delta}{M}$ when this has its *minimum* value. This will be quite close enough for all physical work, except possibly of extreme refinement, and will give rules which may be applied to data of seven or less places of figures, and which may be occasionally relaxed, *with judgment*, in ordinary work. Let the rules be framed for giving the number of *places* to be retained, as this gives the greatest convenience in practice. Now the minimum value of $\frac{1}{10} \cdot \frac{\delta}{M}$ would be that where the first two significant figures in δ were respectively 1 and 0, and in M were 9 and 9; *e. g.*, $\delta = 0.010$, $M = 9.999$. For this case $\frac{1}{10} \cdot \frac{\delta}{M}$ would be $\frac{1}{10000}$th, corresponding to unity in the rth place of M. Then the *accumulated computation error at any stage* must not exceed 1 unit in the rth place of figures. The errors introduced by the rejection of figures beyond the rth place, adding one unit to the figure in that place when the first rejected figure is 5 or over, are distributed according to the first special law, p. 129. Thus the average error will be $\frac{1}{4}$ of a unit in the rth place at each rejection. These errors in a process of several additions or subtractions will accumulate as expressed by XIV., and by the special law of error just referred to. By these jointly it appears, then, that the accumulated error will be proportional approximately to $\sqrt{n}$ where n is the number of rejections. In multiplication or division the accumulation will follow the law of XVI., and XVII. At each step and in the final result the effect of each rejection will remain as the same fractional error of the quantity, though changing in its value in units in the rth place, in consequence of previous multiplications, etc. Thus in the final result the rejection errors as units in the rth place will follow the same law of distribution as at the point where they were rejected, and their combined effect may be computed as approximately proportional to $\sqrt{n}$, as for addition or subtraction. All other arithmetical processes may be regarded as combinations or modifications of the four primary ones. Let us then write as the limit $\frac{1}{4}\ \sqrt{n} < 1$ unit in the rth place, which solved for n gives $n < 16$. If, then, we reject always all places beyond the rth, we shall, on the average, not have in 16 rejections, and hence in any ordinary work, an accumulated computation error beyond the assigned small limit. We have, then, the following rules :—

Rules for significant figures :—1. In the δ ($a\,d$ or $A\,D$) two places of significant figures should in general be retained but the first place will sometimes suffice if the digit in that place is large.

2. In a single observation the last place of significant figures retained should be usually the rth place; viz., that corresponding to the second place of significant figures in the $a\,d$ of a series of such observations. It is sometimes sufficient to retain one place less than this when the digit in the first place of the $a\,d$ is large. In other words, retain the place corresponding to the last place properly retained in the $a\,d$ under rule 1.

3. In a mean or average, retain places to include that corresponding to the second place of significant figures of its $A\,D$. Sometimes one less place than this may suffice. In other words, retain places to correspond to the last place properly retained in the $A\,D$ under rule 1.

4. In addition or subtraction, carry the sum or difference only to that place which corresponds to the second significant figure in the $a\,d$ or $A\,D$ of the *least* precise quantity; *i. e.*, of the one with the largest δ. It will depend on the number and kind of quantities to be added or subtracted whether or not these quantities should each be carried to one place beyond that in which the last figure of the final result is desired, this extra place being rejected in the final result.

5. In multiplication (or division) carry out the product (or quotient) at any stage of the work only to the number of places retained in the original quantity under rule 2 or 3. If several measured quantities are to be multiplied (or divided) into each other, carry the product (or quotient) and the separate factors only to that number of places which would be retained under rule 2 or 3 in the least precise factor. It may sometimes be well to carry known factors, such as π, g, etc., to one place more than this rule would prescribe for the measured factors.

6. In the use of logarithms, the mantissæ should be retained to as many places as there should be places of significant figures retained, under rule 5, in the number corresponding, if the multiplication or division were to be performed directly. The characteristic is not to be considered, as it serves merely to locate the decimal point.

Closeness of corrections, constants, etc. Let M_1 be the mean of a series of observations, and δ_1 be its precision measure as computed from these. Let c be a correction to be added to M_1, and determined by comparison with standard, or in any way whatever, with a computed or estimated precision measure δ_c. Then δ, the precision measure of the corrected mean $M_1 + c$, will, by XIV., be found from $\delta^2 = \delta_1^2 + \delta_c^2$. Now, as already stated, it is obvious that anything producing on M_1 an effect less than about $0.1\ \delta_1$ may be considered as insensible or negligible. Keeping this in view we may obviously have the following cases :—

1. If $c < 0.1\ \delta_1$ the correction may be omitted.

2. If c is of the same order of magnitude as δ_1 it may be neglected only in coarse work, and should be then taken

into account in making up δ. As c, in any case, is of constant sign, this omission is not admissible in fine work.

3. Whatever the value of c, if $\delta_c < 0.1\,\delta$, then $\delta = \delta^1$ sensibly; so that c may be regarded as exact, and δ_c neglected.

4. Whatever the value of c, if $\delta_c > 0.1\,\delta$, then δ_c must be taken into account in making up δ.

Inspection will show that for constants, or other terms added to or multiplied into any quantity, such as M_1 above, the effect on M_1 of rejection of superfluous places of figures, or of errors or deviations in these quantities, may similarly be neglected when less than $0.1\,\delta_1$. Of course in very exact work this margin may be narrowed somewhat; in coarse work it may be broadened.

Estimated precision measures. Circumstances sometimes render it difficult or impossible to obtain the precision measure by direct observation. But in such cases it is often possible to obtain an approximate or estimated δ. A simple estimation of the $a\,d$ may be the best thing available. But usually it is easier to estimate what would be the extreme deviation which might occur in, say, 1,000 readings. Let h denote such an extreme deviation. Now, the general law of distribution shows that the deviation whose frequency is 1 in 1,000, has, in the long run, about four times the magnitude of the average deviation; *i. e.*, $h = 4\,a\,d$, whence an approximate $a\,d$ may be computed from an estimated h. This relation between h and $a\,d$ is often of service in other ways, as for instance where an extreme variation of some kind can readily be observed, but the average cannot.

Example. The following illustrates the application of the foregoing methods: Required the work W done in one stroke by an engine piston of diameter d and stroke s, working at a mean indicated pressure of intensity p as found from an indicator card. $W = \frac{1}{4}\,\pi\,d^2 ps$.

There may be two cases: one in which the data are already determined, and the quality of the result is under scrutiny; the other in which (as should always be done when possible) it is desired to determine in advance of the work what the precision should be in the components.

1. Having given the data and their precision measures, to find what reliance may be placed upon the result. In order to estimate the accuracy of the result, it is essential to inquire first into the accuracy with which the instruments were known, and whether they were properly applied in the measurements. Unless we can obtain suitable information on these points, which properly should go with the original statement of the result, it is impossible to discuss the quality of the result. Suppose, then, that it were further stated that the micrometric apparatus used in measuring the diameter and length of stroke had been tested under proper conditions, and corrections had been determined which brought its indications to agreement with the standard with an $a\,d$ of 0.00030 inch; also that the indicator spring had been checked against a mercury column, and the correction determined to an AD of 0.06 lbs.; also that due care as to temperature effects and all other discoverable sources of error was exercised when the measurements were made, so that it was deemed that no determinate source of error beyond the suitable limits was overlooked.

The data are:—

$d = 10.020$ in $\quad a\,d. = 0.010$ in. $\quad n. = 25. \quad \therefore A\,D. = 0.0020$ in.

$p = 20.00$ lbs. $\quad a\,d = 0.6$ lbs. $\quad n = 10. \quad \therefore A\,D = 0.20$ lbs

$s = 15.04$ in. $\quad a\,d = 0.0040$ in. $\quad n = 1.$

whence $W = 23720.$ inch-lbs.

We have now to find from the observed deviations their combined effect on the result. This is most readily done by separating into the factors $\frac{1}{4} \times \pi \times d^2 \times p \times s$. Of these, $\frac{1}{4}$ is an exact number; and π is a numerical constant known with indefinitely great closeness; so that both of these may be considered by themselves later, and carried to so many places as not sensibly to vitiate the result. Then by XX.

$$\left(\frac{\Delta W}{W}\right)^2 = \left(\frac{\delta\,d^2}{d^2}\right)^2 + \left(\frac{p}{p}\right)^2 + \left(\frac{\delta\,s}{s}\right)^2$$

From XVIII we have $\frac{\delta\,d^2}{d^2} = \frac{2\,\delta\,d}{d}$. Note that we cannot separate into the factors $\frac{1}{4} \times \pi \times d \times d \times p \times s$, because the third and fourth would then *not* be independent. Substituting, then, the numerical values $\delta\,d = 0.0020$ in., $\delta\,p = 0.20$ lbs., $\delta\,s = 0.0040$ in., we have

$$\left(\frac{\Delta W}{W}\right)^2 = \left(2.\frac{0.0020}{10.}\right)^2 + \left(\frac{0.20}{20.}\right) + \left(\frac{0.0040}{15.}\right)^2$$

$$= 0.00\,000\,016 + 0.00\,010 + 0.00\,000\,007 = 0.00\,010$$

$\therefore \frac{\Delta W}{W} = 0.010$ or 1 per cent., and $\Delta W = 0.010 \times 23720. = 240$ inch-pounds.

The number of places to be retained in π is such that the error introduced by the rejected places will not exceed 0.1 to 0.01 of the effect of the δ of the least precise factor in the data, viz., p. Now $\frac{\delta\,p}{p} = 0.0.010$. As π is a factor we have, then, $\frac{\delta\,\pi}{\pi} < 0.1 \times 0.010 < 0.0010$, whence $\delta\,\pi < 0.0010\,\pi < 0.0031$. Hence $\pi = 3.142$ will be exact enough. A better illustration of this point occurs in the second part of this example.

From this result for $\Delta\ W$ we know that the $a\,d$ of W is 240 inch-pounds, and that $\frac{a\,d}{W} = 0.01$, or 1 per cent. And as it has been shown that due regard has been paid to keeping the determinate errors suitably below the deviations, we are justified in using this value of $\Delta\ W$ as our estimate of the reliability of the result, as it is the best estimate which we can form. That is, other measurements made with a corresponding grade of care, but with wholly different instruments, would *probably* give results agreeing with this *on the average* to about one per cent. Unsuspected errors may, of course, exist, and of a nature not to be eliminated by averaging—whence the word "*probably*." For instance, it might have occurred that the indicator spring had received an unsuspected injury subsequent to test.

From the numerical values in the above expression for $\left(\frac{\Delta\ W}{W}\right)^2$, it will be seen at a glance that the precision in p is much too small as compared to that in d and s. Hence much of the labor spent in measuring the latter was thrown away. This might have been prevented, and the needful care might have been determined beforehand by the solution to be now given.

2. Required to determine in advance of the measurements, and from rough values, the necessary precision in the various components. The problem would be stated thus:—

Desired the work, W, done upon the piston of a steam engine in a single stroke under the indicated pressure p of about 20 pounds, the stroke s being about 15 inches, and the diameter d about 10 inches. Accuracy wished for in W is 1 in 1,000., or 0.1 per cent. How closely must the values of d, s, and p be measured, and how far should π be carried out?

Separate into factors the expression of W, as before, and lay aside the constants $\frac{1}{4}$ and π. Then imposing the condition of equal effects of the δ's upon the result, we have

$$2\,\frac{\delta\,d}{d} = \frac{\delta\,p}{p} = \frac{\delta\,s}{s} = \frac{1}{\sqrt{3}}.\ \frac{\Delta\ W}{W} = \frac{1}{\sqrt{3}} \times 0.001 =$$

0.00058

$\therefore\ \delta d = \frac{1}{2} \times 0.00058 \times 10. = 0.003$ inch.
$\therefore\ \delta p = 0.00058 \times 20. = 0.012$ pounds.
$\therefore\ \delta s = 0.00058 \times 15. = 0.009$ inch.

For the constant π we should have the requirement that $\frac{\delta \pi}{\pi} < 0.01 \times 0.00058 < 0.00006 \therefore \delta \pi = 0.00006 \times 3.1 = 0.00019$; whence $\pi = 3.1416$ would amply suffice.

It thus appears that for the assigned limit of accuracy $\frac{\Delta W}{W} = 0.001$, we must have the average deviations of d, p, and s respectively not over 0.003 inch, 0.012 pounds, 0.009 inch; and all determinate errors must have been so far removed from the work, by corrections and otherwise, that their residuals may safely be classed among the indeterminate errors. These δ's must include the average deviations not only of the direct measurements in each case, but those of the corrections used also, as stated in the paragraph on closeness of corrections.

(*To be continued.*)

ON THE PROPER SHAPE FOR ARMATURE CORES IN DYNAMO-ELECTRIC MACHINES.[1]

BY W. L. HOOPER.

It is now conceded that the wire upon the sides and inner surface of a Gramme ring and upon the ends of a drum is idle; only the conductors upon the face of an armature being actively engaged in the generation of electromotive force. Accordingly, the drum has been made long that the largest possible amount of wire might lie upon its face; and the wire upon the inner surface of a Gramme armature has been made active by the employment of auxiliary poles placed within the ring. But has the activity of the whole armature wire been thereby increased? At first sight it would appear that of two armatures having the same length of wire, that having the greatest length actively employed in cutting lines of force would generate the highest electromotive force. But let us look at an actual case. Suppose a Gramme ring having a core two inches square and provided with both external and internal poles. Let the magnetization of the core be just below saturation, this condition being acquired by the passage of n lines of force. There is a half revolution, of the eight inches of wire in a single turn; two inches on the face of the armature will cut $2n$ lines and the two inches on the inside wire cut the same number, making n lines of force cut by a single turn of wire, half of which is active. Now it is well known that it is perfectly easy to saturate the core of a Gramme ring without internal poles; in which case there are n lines of force cut by a single turn as before; though they are now cut by the two inches on the face of the ring. It is thus seen that the electromotive force depends solely upon the number of lines of force cut by a turn of wire, not at all upon what fraction of the length of that turn may be active. Furthermore, since it is well known that internal poles tend greatly to increase magnetic leakage, it is quite certain that the magnetization of the cores will be obtained with the least expenditure of energy in the field magnets when only external poles are employed.

The drum or cylinder armature is sometimes made several diameters in length. Let us compare such an armature two feet long and six inches in diameter with one a foot long and a foot in diameter. Both will have a magnetic cross-section of one square foot; moreover, they will present about equal surfaces to the pole-pieces. A single turn of wire in either will cut $4n$ lines of force in a complete revolution; but while the long armature contains only half the length of dead wire, it contains 25 per cent. more wire in all, and yields the same electromotive force. Moreover, to get the same strength of field in the machine with the long armature, much more wire will be used and electrical energy expended.

Theory then demands that for any armature there shall be the greatest possible cross-section of iron with the least possible length of wire. This indicates a circular cross-section for the iron core of a Gramme ring and a spherical form for the Siemens armature. I think it probable, however, that mechanical considerations favor a flat faced armature; but in obtaining this the conditions above imposed should be departed from as little as possible.

1. Read before the American Academy of Arts and Sciences, April 11, 1888.

ON DYNAMOMETERS.

BY HEFNER ALTENECK.

Translated from the *Electrotechnische Zeitschrift*, December 1887, for the ELECTRICAL ENGINEER, by J. HOWARD PRATT, Jr.

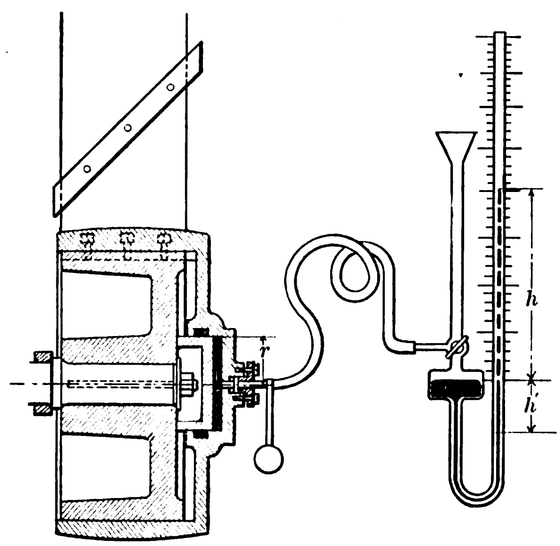
I INTEND in the following article to bring to your notice a new contrivance which is intended to serve for the determination of force, and which is used at the works of Siemens and Halske for testing dynamo-electric machines. The characteristic feature of this consists in bringing to equilibrium by hydraulic means the force to be measured.

About two weeks ago, Mr O. H. Müller, of Charlottenburg sent to me, for my opinion, designs of a registering dynamometer, which though different in its details of construction, nevertheless was devised upon a practically similar principle. This prompts me to delay no longer the publication of the older machine which was invented in March of this year [1887], and to my knowledge is the first dynamometer with hydraulic transmission.

I may, perhaps, assume it as known that, not only at the works of Siemens and Halske, but, following our precedent, at several other places also, force is measured in belting by means of an apparatus in which both parts of the belt, the actuated and the actuating, are strained equally and symmetrically from their direct tension by a pair of pulleys joined together or by one pulley laid between them. The force with which the pair of pulleys or the single pulley tends to be deflected to one side of its middle position is proportional to the difference in tension of the belts, *i. e.*, to the force to be measured. This is determined by means of a spring balance attached to the instrument. The older form of this dynamometer, namely that with the two movable pulleys, furnishes more accurate results, but requires for every time it is used a separate careful adjustment and measurement of the sag of the belts. Therefore, the other form of apparatus, which has only one movable pulley and besides that only a little gearing, and which requires no accurate adjustment, has come into more general use. While it can be regarded an advantage of this dynamometer in comparison with other systems that all pulleys run with relatively very slight pressure and, therefore, the friction of their bearings and other resistance to motion are comparatively very small, still the measurements by this method may, under unfavorable circumstances, prove a few per cent. too high. For most cases, and especially for the practical needs of measurement of forces in dynamo-electric machines, the degree of accuracy attained is still abundantly sufficient; however, for theoretical investigations, particularly in the case of electrical transmission of energy, it is valuable to have an equally simple and yet more accurate method. The hydraulic dynamometer, a design of which in cross-section is given in the accompanying cut, is intended to serve this purpose.

The main feature of the apparatus consists merely in a modification of the actuated pulley which still retains its exterior diameter.

The rim of this pulley only loosely surrounds the inner core, which, as usual, is fastened to the shafting, and is faced cylindrically on the outside. The mechanical union of the two parts is effected at their surface of contact by four equally separated so-called "tongue and grooves." These are arranged, not as usual and as is represented in the cut for the sake of greater clearness, in a direction parallel to the axis, but in a helix inclined 45° to it. The core of the pulley, accordingly, forms a screw of several threads with steep pitch and large diameter, the rim forming the female screw. The consequence of this is that every force of rotation which acts upon the circumference of the pulley tends at the same time to move the rim of the pulley tangentially upon the core in the direction of the axis. The direction of the screw is so chosen with reference to the direction of revolution of the pulley, that this displacement occurs towards the instrument. The rim of the pulley is closed in front by a partition which covers the face of the core. In the middle of this



partition on the side towards the core is found a cylindrical hole, in which is fitted a plunger that rests against the face of the core. The fitting is done in the old approved way, as in the hydraulic press, by circular washers. The space between the plunger and the front partition communicates by a small hollow cylinder and rubber tubing with an ordinary mercury manometer. The cylinder is conducted from without through packing, and outside is kept in some way from revolving. The space between the plunger and the partition, the cylinder, and the tubing, including the space over the mercury surface, are filled with a light fluid (preferably glycerine), for which a funnel, a three-way cock and, in the hollow space, an air vent that can be closed, are conveniently arranged.

From all this it is clear that the force of rotation of the belt is transmitted to the fluid enclosed between the plunger and the outer partition, with a total stress equal to that which it exerts on the radius of the thread of the screw at 45° inclination. In consequence of this, the enclosed fluid exerts in all directions, according to the well-known hydraulic law; upon each unit of surface, a pressure equal to the pressure on the plunger divided by the surface of the plunger. Just as in the hydraulic press from a small plunger to a large one, only by a reverse process, this pressure is transmitted to the mercury manometer, and is indicated there by the height of the mercury column, which is read on a long scale.

Neglecting the corrections mentioned below, the height of the mercury is proportional to the force to be measured.

It might be supposed that in the method described for mechanical transmission, friction on the thread of the screw and the plunger would prevent accuracy. Here, however, was again absolutely confirmed an observation which I had already had frequent opportunity to make, namely, that friction in well adjusted apparatus is never troublesome if all the parts are in motion or are under the influence of vibrations. Although the friction between the rim and the core of the pulley at rest is very great, because the entire strain of the tension of both belts is here exerted, nevertheless its injurious effect disappears entirely if the pulley is revolved.

The height of the mercury column changes up and down about a millimeter for every slight variation in the force to be measured, by which the proof that it is permanently influenced by no kind of friction is practically established.

On the other hand, the influence which the centrifugal force of the fluid rotating with the pulley exerts on the manometer, at least when the number of revolutions is great, must not be neglected. This, however, can be reckoned and the necessary correction can be obtained from a table. It is known that the surface of a fluid rotating in a circular vessel is heaped up at the edge, and, on the whole, assumes the form of a paraboloid. So, on being rotated, the enclosed fluid, in consequence of centrifugal force, exercises, not only against the periphery but also against the lateral faces, a pressure which is greatest at the circumference and nil at the centre. Suppose first the centrifugal force acting alone, a total pressure will be felt against the front partition of the fluid receptacle, which is equal to the sum of all the pressures against it, provided only that it cannot yield to this pressure. Because, however, this goes on without interruption as long as liquid can flow in at the centre, an expression for the entire pressure is obtained in that for every element of surface, a pressure which is equal to the mean value of the total centrifugal pressure, is introduced as a negative factor. This mean negative pressure, (according to the principle that the volume of a paraboloid is equal to half the volume of the circumscribing cylinder), is equal to half the maximum pressure exerted at the circumference. In the middle, where the cylindrical tube opens and there is no centrifugal force, this pressure reaches its full value and exerts a retarding action, which diminishes the height of the mercury in the manometer tube.

To determine the constants of the instrument the following method is best. First of all, one cannot be sure that the inclination of the thread really amounts to 45°; or, rather, one must determine on which radius that is the case. As is known, the inclination of an ideal screw-surface decreases in proportion to the radius on which it is measured. So, after taking away the rim, draw on the circumference of the core a straight line parallel to the axis. Restore the rim and revolve it any distance on the core. Measure not only the magnitude of this revolution in the displacement of the circumference of the inner surface of the rim with reference to the line that was drawn, *i. e.*, the corresponding length b, of the radius of the plunger, R, but also the simultaneous displacement a, on the line drawn. Now let R be that radius on which the inclination of the thread is as 1:1 (*i. e.*, 45°), then

$$R = \frac{a}{b} R^1.$$

The force acting on radius R, is transmitted to the plunger in this ratio.

Moreover, let

r = radius of plunger in meters,
h = difference in level of the two mercury surfaces in the manometer.
h^1 = (in centimeters) the height of the mercury column due to centrifugal force.
S = specific gravity of the enclosed fluid (for glycerine = 1.26).
n = number of revolutions per minute.
P = the force acting on the radius R (where the inclination of the screw is 45°) = the pressure on the plunger.
N = the horse-power transmitted through the pulley.

Then

$h^1 = 0.00206\ n^2\ r^8\ s.$

$P = 425.6\ r^2\ (h + h^1).$

$N = 0.594\ R\ r^2\ n\ (h + 0.00\ 206\ n^2\ r^2\ s).$

R and r, taken in meters, h and h^1 in centimeters, specific gravity of mercury, 13.55.

It is seen from these formulæ that it is only necessary to take r sufficiently small to make the $h+h'$ corresponding to a force P, appear as large as you please. There is no objection to making the scale of the manometer a meter or more in length, by which is secured an extraordinarily distinct reading and sensitiveness of the indicator. The damping of oscillations, essential in all such apparatus and often so difficult to secure, is, notwithstanding, perfectly attained in consequence of the friction of the liquid in the tubes, which, by merely turning the cock, can be regulated at will.

If the hydraulic dynamometer be compared with the belt-dynamometer, the latter has, to be sure, the advantage that its use requires no contrivance on the machine itself, and the same instrument, within its limits of work, can be used for every machine immediately. On the other hand, however, its use as a fixture for continual control of a machine is as good as excluded, because no one will burden himself with its permanent adjustment and maintenance, as well as its noisy action.

For just this purpose the hydraulic dynamometer is very useful, because it has no superfluous gearing and takes up almost no room, and, indeed, is scarcely noticeable in the outward appearance of the machinery. The scale can be fixed at any desired point (for example, the wall of the machine shop) and made visible at a distance. It is to be recommended for this case to arrange instead of the funnel a small force-pump, so that, if the fluid should in time be lost through some incompactness in the material, it can be continually replenished even during its action and without disturbing the measurement. The amount of enclosed fluid is immaterial for the measurement.

The hydraulic dynamometer can be employed for small as well as for infinitely great forces to a degree that is true in no other systems. With slight mechanical changes also it can be made self-registering for a projecting axle or put in connection with a clutch instead of a pulley. I believe, therefore, that it will do good service in many cases. At any rate, the practical engineer will easily be able to judge whether the new apparatus or the older belt-dynamometer is better adapted for an individual case.

I feel myself constrained still to add to the preceding communication a rejoinder to a circular which is published by the firm of Ganz & Co., in Buda-Pesth, and in which a belt-dynamometer constructed by that firm is recommended as preferable, while to the "well-known dynamometer of Von Hefner-Alteneck" is summarily ascribed an uncertainty and liability to error which would make it as good as useless for modern technique. The dynamometer described in the circular is constructed as a separate piece of apparatus, which makes necessary, in all, three separate belts. The middle one runs over four pulleys, each of which it half encircles—two stationary and two fitting on a common movable piece, which revolves about a fixed point with the force of the difference of tension of the belts. The working of this apparatus rests, then, on the same principle as the already-mentioned much older belt-dynamometer without special belts; yet with this distinction, that the index remains approximately correct for a greater deflection of the movable piece and can thus be used for registering. By a whole page of computations it is then shown that the limits of error of the instrument do not exceed $\frac{8}{1000}$ per cent.

It is, then, perfectly plain that from the similarity of the principle, almost the same calculation—its correctness being assumed—must also serve directly for the older instrument, condemned as inaccurate by Ganz & Co., and thus at least an equal accuracy be ascribed to it also. Unfortunately, however, the result of the computation as well as the conclusion drawn from it, that from an assumed zero-point the resistances of the apparatus are constant and therefore may be eliminated, is not borne out by the facts; for, in the single pulley over which the belt runs, the resistances of motion influencing the result are dependent not only on the transmitted power, but also on the initial tension.

There is, then, nothing left but to make the initial pressure which these resistances produce as small as possible. On more careful investigation, however, it is found that in the older instrument this injurious pressure enters to a far less extent than in that of Ganz, because not the full traction of the single parts of the belting, but only small components of them, which also partly neutralize each other, affect the pulleys. Just so, too, the further criticism raised, that in the older instrument, pivots instead of knife-edges are used, has no weight. According to the already related experience, by using the latter, which are exposed to violent vibrations, accuracy is in no case increased, while durability is lessened. The unfavorable opinion of the older instrument given by Ganz & Co. lacks, then, any foundation in fact.

THE MAXIMUM EFFICIENCY OF INCANDESCENT LAMPS.[1]

BY JOHN W. HOWELL.

THE word efficiency, when applied to an incandescent lamp, is used to designate the amount of energy required by the lamp for the production of a given amount of light; thus we say that a given lamp has an efficiency of three watts per candle, at 16 candles, meaning that to produce

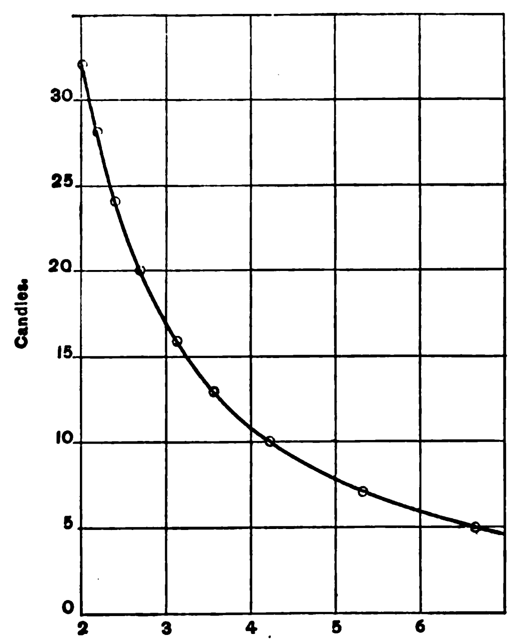


Fig. 1.

an illumination of 16 candles we must supply the lamp with 48 watts.

The word efficiency, when applied to a prime mover or to any piece of apparatus that changes energy from one form to another, or which transmits or utilizes energy, has a well defined meaning, and is used to represent the ratio of the energy of the useful effect produced by the apparatus, to the energy necessarily supplied to the apparatus to enable it to produce that effect.

An incandescent lamp transforms electrical energy into heat and light; so the use of the word efficiency to denote

1. A paper read before the American Institute of Electrical Engineers, April 10, 1888.

the watts per candle required by the lamp is not a proper one. To denote properly the efficiency of an incandescent lamp we must be able to separate the energy of the light produced by it from the energy of the heat produced. Then the ratio of the energy of the light to the electrical energy required by the lamp will be a correct expression for the efficiency of the lamp, and we will have to find

Curve showing lives of equally good lamps, burned at different efficiencies.

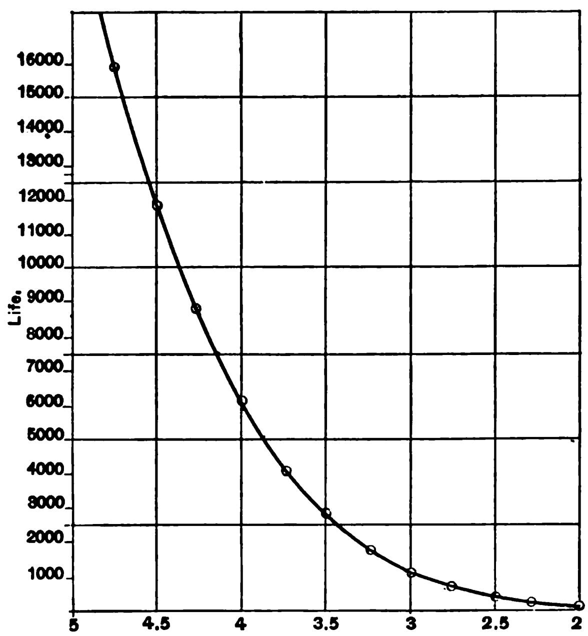
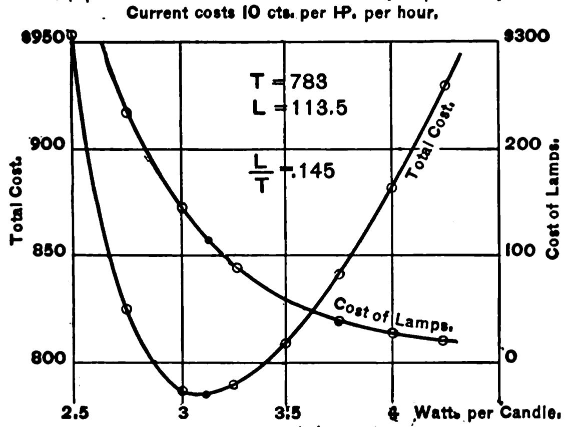


Fig. 2.

some other word to designate the watts per candle. In this paper the word efficiency is used in its ordinary improper sense to denote the watts per candle required by a lamp when producing a given amount of light.

Lamps 85 cts. each—Life 600 hrs. at 3 Watts per Candle. Current costs 10 cts. per HP. per hour.



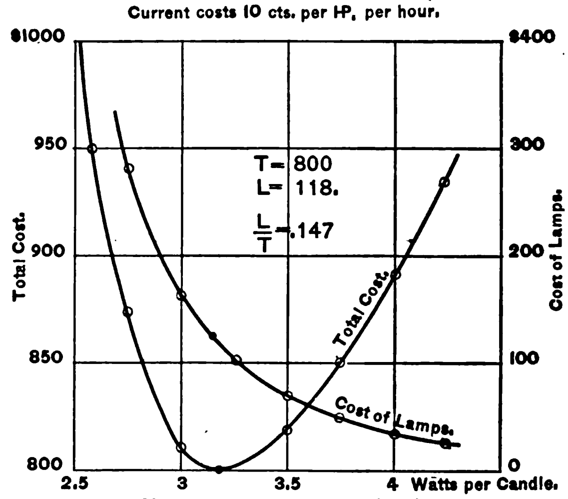
Minimum at 3.1 Watts per Candle.
∴ Maximum Efficiency 3.1 Watts per Candle.

Fig. 3.

The efficiency of a lamp varies with its candle-power. The curve, figure 1, shows the rate of this variation for a particular lamp. At five candles this lamp has an efficiency of 6.7 watts per candle; at 10 candles it is 4.2 watts per candle, and at 20 candles it is 2.66 watts per candle.

Any statement regarding the efficiency of a lamp must, therefore, be accompanied by a statement of the candle-power at which it has the stated efficiency; without this it is meaningless. There is nothing in an incandescent lamp itself that fixes its proper efficiency or in any way indicates what it is. The lamp from which the curve, figure 1, was determined has, within the limits of the curve, any efficiency between two and seven watts per candle. Thus, by simply changing the candle-power of the lamp, we can operate it at any efficiency we choose, and get as much or as little light per watt as we choose.

Lamps $1.00 each—Life 600 hrs. at 3 Watts per Candle. Current costs 10 cts. per HP. per hour.

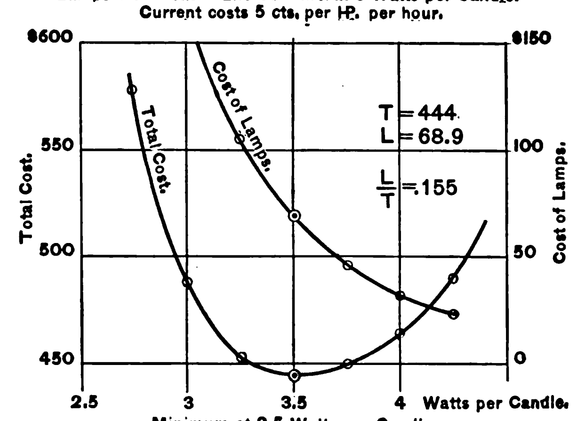


Minimum at 3.18 Watts per Candle.
∴ Maximum Efficiency 3.18 Watts per Candle.

Fig. 4.

In commercial practice the candle-power of lamps is always marked on them, and their efficiency at this candle-power is stated; but even this is not a proper index to the value of the lamp or to its proper efficiency. Experience has shown that lamps are almost universally run above their normal rating; lamps rated at 4.5 watts per candle are usually run at from 3.5 to 4 watts per candle, and in order to make lamps that will stand the strain of being run above their rated capacity, it is necessary to rate them considerably below the efficiency at which they will give the best results under ordinary circumstances.

Lamps $1.00 each—Life 600 hrs. at 3 Watts per Candle. Current costs 5 cts. per HP. per hour.



Minimum at 3.5 Watts per Candle.
∴ Maximum Efficiency 3.5 Watts per Candle.

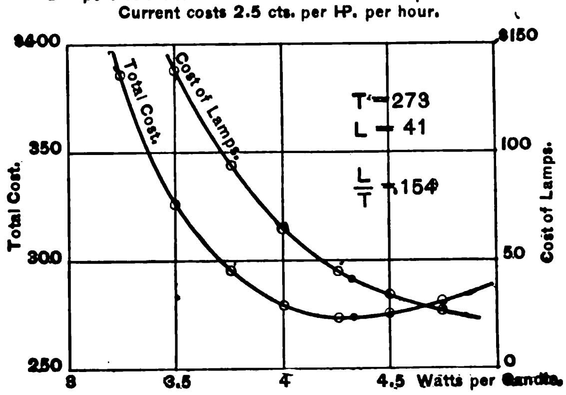
Fig. 5.

Lamps have been made and sold in England which have a very high rated efficiency, but parties buying these lamps are told that they will get very much more satisfactory results if they run the lamp *below their rated capacity.* So we see that some lamps are rated above their capacity and some are rated below, and the rated efficiency of a lamp is not always the best efficiency at which to run it. How, then, are we to determine the efficiency at which a lamp will give the best results? It is this question which I will attempt to answer.

The term "maximum efficiency" of a lamp, as used in the title of this paper, does not mean the highest efficiency at which a lamp can be operated, but the efficiency at which the best results are produced by the lamp: or more accurately, *the efficiency at which the cost of operating the lamp is a minimum.*

Taken in this latter sense, the maximum efficiency of a lamp is not its highest efficiency. As we increase the candle-power of a lamp its efficiency increases; consequently, by running the lamp high enough we can make its efficiency so high that very little power is required to produce a given amount of light and the cost of the power to produce the light is very small. But, while the efficiency of the lamp increases, its life decreases, and if we run a lamp at too high an efficiency, the saving in the cost of power is more than balanced by the increased cost of lamp renewals.

Lamps $1.00 each—Life 300 hrs. at 3 Watts per Candle.
Current costs 2.5 cts. per HP. per hour.

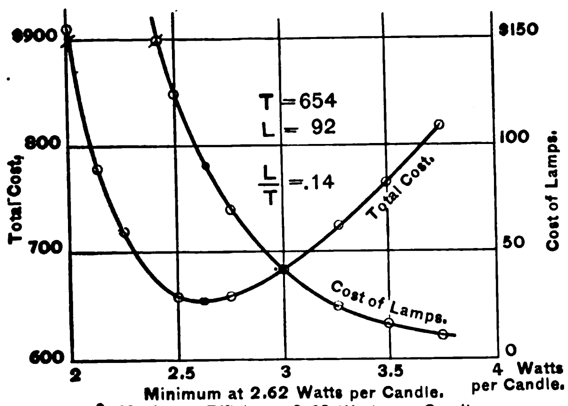


Minimum at 4.32 Watts per Candle.
Maximum Efficiency 4.32 Watts per Candle.

Fig. 6.

To determine the maximum efficiency for lamps under given conditions we must determine the efficiency at which the sum of the costs of power and lamps is a minimum, and in order to do this we must know the rate of variation of the life of a lamp with its efficiency.

Lamps 50 cts. each—Life 1200 hrs. at 3 Watts per Candle.
Current costs 10 cts. per HP. per hour.



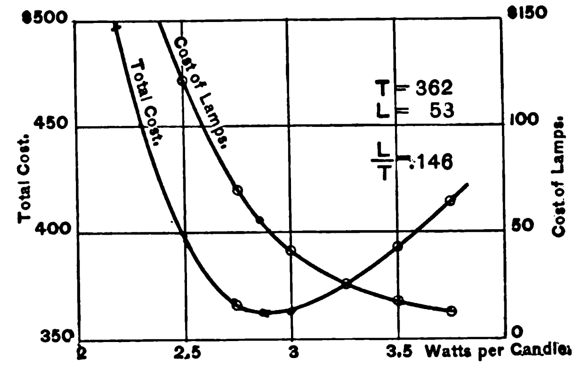
Minimum at 2.62 Watts per Candle.
Maximum Efficiency 2.62 Watts per Candle.

Fig. 7.

The curve, figure 2, shows this rate of variation. This curve is the result of very carefully conducted experiments made by the Edison company. These experiments extended over five years and consumed a very large number of lamps. Its accuracy when applied to Edison lamps is beyond question; but our experiments with lamps having an artificial surface on the carbon, or "flashed" lamps as they are called, show that their rate of variation of life and efficiency follows a different curve.

This curve does not apply to individual lamps. If we take two Edison lamps and burn them at different efficiencies, their lives for these efficiencies will probably not be such as indicated by the curve, nor will they be proportioned to these indicated lives. But if we take 100 lamps and burn them at one efficiency, and another hundred equally good lamps and burn them at another efficiency, the average lives of the two sets will be proportional to the lives indicated by the curve for these two efficiencies.

Lamps 50 cts. each—Life 1200 hrs. at 3 Watts per Candle.
Current costs 5 cts. per HP. per hour.

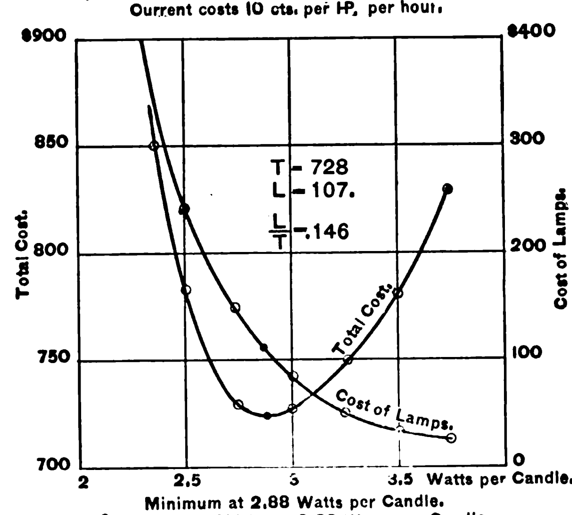


Minimum at 2.825 Watts per Candle.
Maximum Efficiency 2.88 Watts per Candle.

Fig. 8.

In order to determine at what efficiency the cost of operating lamps of a given quality under given conditions is a minimum we must calculate what this cost is at different efficiencies. To do this we consider the total cost of operating the lamps to be made up of two parts, viz., the cost of the *current* and the cost of the *lamps.* The cost of the current is made up of every expense incurred in operating the lamps, including materials consumed, labor, taxes, insurance, rent, and every other expense incurred in operating the plant, except the cost of lamps.

Lamps 50 cts. each—Life 600 hrs. at 3 Watts per Candle.
Current costs 10 cts. per HP. per hour.



Minimum at 2.88 Watts per Candle.
Maximum Efficiency 2.88 Watts per Candle.

Fig. 9.

The cost of the lamps is an item by itself, and is the amount which the lamp has cost when it is put in use. This is a natural division of the total cost of operating a plant, since to produce light by incandescence all that is necessary is a lamp and current to operate it.

If, in any case, we know the cost of the current required to operate the lamps, the cost of the lamps, the quality of the lamps,—that is, the life they will give when burned at a given efficiency,—and the rate of variation of their life with efficiency, we can then calculate at what efficiency the

cost of operating the lamps is a minimum, and this I call the maximum efficiency of those lamps.

The following examples show what this maximum efficiency is under varying conditions of the cost of lamps—the cost of current and the quality of the lamps. The cost of the lamps I have varied between 25 cents and $1.00 each. The cost of current varies between 2.5 cents and 10 cents per h. p. per hour. The quality of the lamps varies between 300 hours life at 3 watts per candle, and 2,400 hours life at 3 watts per candle.

In each of the following cases I have calculated the cost of operating 100 16 c. p. lamps 1,000 hours, at each of the efficiencies comprised in the curve of total cost. These curves do not show the cost of running the same lamps at different efficiencies, but the cost of running equally good 16 candle lamps of the different efficiencies.

The first case we will consider is shown in the diagram figure 3. In this case the lamps are assumed to cost 85 cents each, and to have a life of 600 hours at 3 watts per candle. The current is assumed to cost 10 cents per h. p. per hour.

The cost of the current is determined from the following formula :—

$$\text{Current cost} = \frac{\text{w. p. c.} \times 16 \times 100 \times 1{,}000 \times \text{cost of ct. per h. p. per hour}}{746}$$

And the cost of lamp from this formula :—

$$\text{Cost of lamps} = \frac{\text{cost of one lamp} \times 100 \times 1{,}000.}{\text{Life at given efficiency}}$$

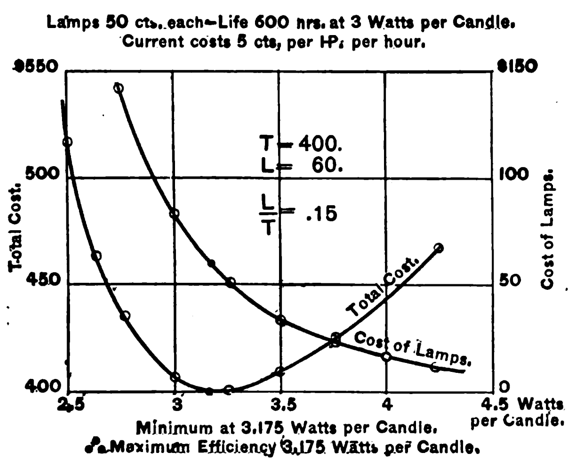


Fig. 10.

The curve marked *total cost* shows the total cost of running 100 10 c. p. lamps 1,000 hours, the efficiencies of the lamps varying between 2.5 and 4.25 watts per candle. The efficiencies are shown by the vertical lines, referring to the scale at bottom. The value of the total cost at any point of the curve is shown by the horizontal line through the point, referring to the scale at the left of the diagram.

The lowest point of the curve shows the point where the total cost is lowest. This is the minimum cost of operating these lamps under the given conditions. The mark at the lowest point of the curve shows this minimum cost to be $783, and a vertical line through this point to the scale at bottom of the diagram shows that this total cost is a minimum when lamps having an efficiency of 3.1 watts per candle are used.

Thus the maximum efficiency of these lamps under the conditions assumed is 3.1 watts per candle.

The lamps considered in the case, shown in figure 4, cost $1.00 ; all other conditions are the same as in the case shown in figure 3. This increases the total cost from $783 to $800, and necessitates using lamps of 3.18 watts per candle instead of 3.1, to make the cost of operating a minimum.

In the case shown in the diagram, figure 5, the current costs 5 cents per h. p. hour ; the other conditions are the same as in the case assumed in figure 4. The minimum total cost in this case is $444, and to make this cost a minimum we must use lamps having an efficiency of 3.5 watts per candle.

In this case, shown in figure 6, the lamps cost the same as in the last, but are only half as good ; the current costs just half as much as in the last case. The minimum total cost in this case is $273, and the maximum efficiency of the lamps is 4.32 watts per candle.

In the case shown in figure 7, the lamps cost 50 cents and have a life of 1,200 hours at 3 watts per candle. The current costs 10 cents per h. p. per hour. This is the cheapest and also the best lamp we have yet considered, but the current is expensive. In this case the minimum total cost is $654 and the maximum efficiency of the lamps is 2.62 watts per candle. In this case, figure 8, the current costs half as much as in the previous case, other conditions being the same. The minimum total cost is reduced from $654 to $362. The maximum efficiency in this case is 2.88 watts per candle. In figure 9, the current costs twice as much as in the previous case, and the lamps are only half as good. The minimum total cost is doubled, but the maximum efficiency is the same as in the previous case.

In this case, figure 10, the current costs one-half of that assumed in the previous case, other conditions being the

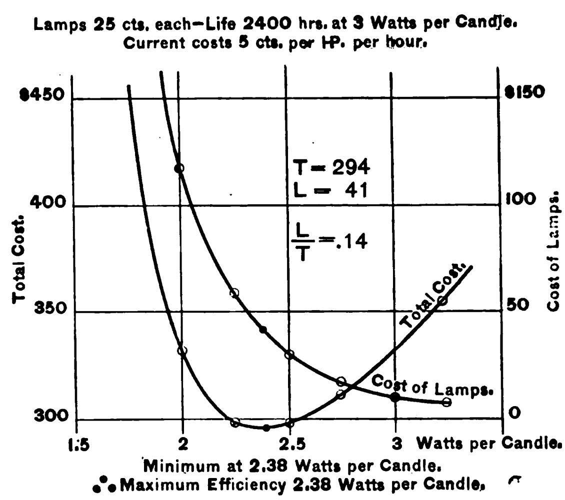


Fig. 11.

same. The minimum total cost is $400, and the maximum efficiency is 3.175 watts per candle.

The curve, figure 11, illustrates the case of very cheap and very good lamps, with moderate cost of current. The minimum total cost is low, $294, while the lamps are run at the high efficiency of 2.38 watts per candle.

In the case shown in figure 12, the cost and quality of the lamps are the same as in the previous case, but the current costs twice as much. This increases the minimum total cost from $294 to $535, and raises the maximum efficiency to 2.14 watts per candle.

In the case, figure 13, the cost of lamps and the cost of current are the same as in the case shown in figure 11, but the lamps are only half as good. The minimum total cost is increased from $294 to $327 and the maximum efficiency is reduced from 2.38 to 2.62 watts per candle.

The first and plainest inference drawn from these curves is that the maximum efficiency of any given lamp is not a fixed one, but varies with conditions outside the lamp itself. Identical lamps operated under different conditions of cost of current must be burned at different efficiencies to make the cost of operation a minimum for the production of a given amount of light. In order to determine the maximum efficiency of lamps, therefore, we must know the quality of

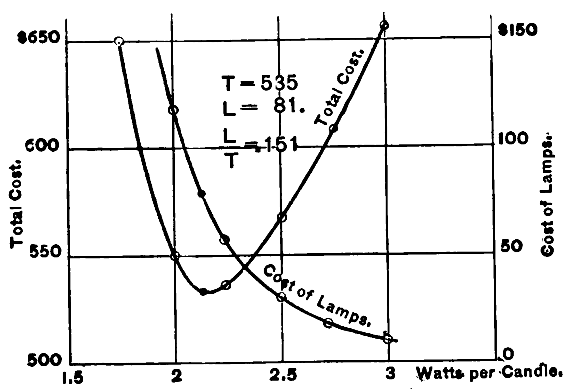
the lamps referred to some standard, the cost of the lamps to the consumer, and the cost of current under the actual conditions existing at the place where the lamps are to be used

In the eleven cases shown in this paper the lamp of highest efficiency is obtained in the case shown in figure 12. This is a case where the lamps are very cheap and very good, and current is very expensive. The lamp having the lowest efficiency is obtained in the case shown in figure 6, in which the lamps are poor and high-priced and the current is very cheap.

There is a marked difference in the sharpness of these curves at the minimum points. An inspection will show that the sharpness of the bend in these curves depends upon the cost of the current, the curves in which the current costs 10 cents per h. p. per hour being the sharpest. Those in which the current costs 5 cents are next, and the one, figure 6, in which the current costs only 2½ cents per h. p. per hour, is very flat at the bottom or minimum point. In this comparison figure 7 is not considered, as it is drawn on a different scale from the others, and is not as sharp as it should be.

This indicates that the more expensive the power is, the more carefully must the lamp efficiencies be chosen. In figure 12, which shows the sharpest curve, a very slight variation in the efficiencies of the lamps makes a very great change in the total cost of operation.

Lamps 25 cts. each—Life 2400 hrs. at 3 Watts per Candle.
Current costs 10 cts. per HP. per hour.



Minimum at 2.14 Watts per Candle.
⁂ Maximum Efficiency 2.14 Watts per Candle.

Fig. 12.

In the case shown in figure 6, in which the current is very cheap, we find that a very considerable change in the efficiency of the lamps used makes very little difference in the total cost of operation.

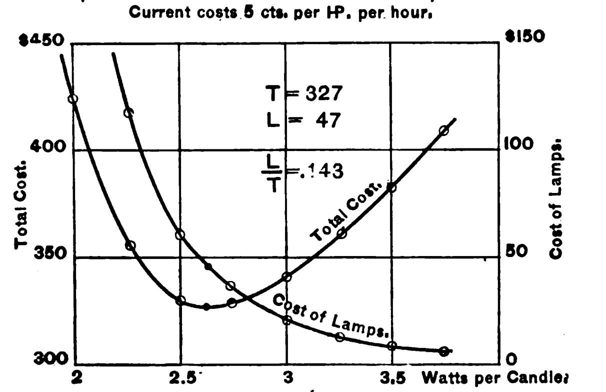
On each of the eleven plates two curves are drawn, one showing the total cost of operation, and the other showing the cost of lamps. On each of the curves showing the cost of lamps a point is marked which indicates the cost of the lamps when the total cost is a minimum. The letter T marked on each of the figures denotes the minimum total cost of operating the lamps under the given conditions. The letter L denotes the cost of the lamps when the total cost is a minimum; and the expression $\frac{L}{T}$ denotes the ratio of the cost of lamps when the total cost is a minimum, to the minimum total cost. An examination of all these curves shows that while the minimum total cost varies with each of the three quantities—price of lamps, quality of lamps and cost of current—nevertheless, *the total cost is always a minimum when the cost of lamps is about* 14.5 *or* 15 *per cent. of the total cost of operation.*

This figure varies somewhat in the different examples considered, but the variation seems to follow no law. In figures 6 and 12 which show the highest and lowest efficiency lamps the figures are 15.1 per cent. and 15.4 per cent. respectively.

The steepness of the curve showing the cost of lamps, and the difficulty of determining the exact minimum point of a curve which has been drawn by inaccurate methods makes it difficult to get the cost of lamps accurately when total cost is a minimum. These curves and values are given just as they were determined, and no effort has been made to bring the results into closer agreement, as could readily have been done. I consider the variation shown by these curves to indicate closely enough that this ratio of cost of lamps to total cost at the minimum point is nearly, if not quite, constant, and that its value is between .145 and .15.

This establishes a very simple law for determining whether or not lamps are being operated at their maximum efficiency; for if they are, the lamp bills will be about 15 per cent. of the total operating expenses of the plant. If the lamp bills are more than 15 per cent. of the total operating expenses the lamps are being burned above their maximum efficiency, and lower efficiency lamps should be obtained. If, on the other hand, the lamp bills are less than 15 per cent. of the total expenses of the plant the lamps are being burned below their maximum efficiency, and higher efficiency lamps would reduce the cost of operating the plant. Where fuel is high priced, or where other causes operate to make the cost of generating current high, it is specially important to use lamps of the maximum efficiency; for we have seen from the above curves that where the cost of current is high the use of lamps whose

Lamps 25 cts. each—Life 1200 hrs. at 3 Watts per Candle.
Current costs 5 cts. per HP. per hour.



Minimum at 2.62 Watts per Candle.
⁂ Maximum Efficiency 2.62 Watts per Candle.

Fig. 13.

efficiency is a little above or below the maximum efficiency attainable under the conditions of operation, makes a very marked increase in the operating expenses of the plant.

If in any plant the lamp bills are only 10 per cent. of the total expenses, then *increasing the efficiency of the lamps by increasing their candle-power does not diminish the total cost of operating the plant.* In order to reduce the total cost *the lamps must be replaced by lamps of the same candle-power but of higher efficiency.* If the efficiency of the lamps is increased by raising their candle-power, the cost of operating the plant *per unit of light produced* is reduced, but the total cost is increased. A plant which is paying less than 15 per cent. of its total expenses for lamps, and which brings the lamp bills up to 15 per cent. by increasing the candle-power of the lamps does not decrease the cost per lamp of operating the plant but *does* decrease the cost per candle of light furnished. If they are paid for the increased light given by the lamps the efficiency of the plant is made a maximum for the existing conditions; but if they are not paid for the additional light furnished the efficiency of the plant is reduced.

This law enables any one operating an incandescent lamp plant to determine whether or not he is using the most suitable lamps for his plant. If the conditions of operation of a new plant are all known, and the quality of the lamps made by any lamp maker is known, we can determine before starting what is the most economical lamp to use.

THE DEVELOPMENT OF THE MERCURIAL AIR PUMP.[1]

BY PROFESSOR SILVANUS P. THOMPSON, D. SC., B. A.

(Continued from page 175.)

THE Toepler form of pump has received in recent years various modifications. E. Wiedemann[2] altered the overhead tube, H, by joining it at its base with two of Gimingham's air-tight joints, allowing it to be removed to be cleaned. Neesen[3] added the side-tube shown at N, in figures 18 and 33, to prevent the top of the pump-

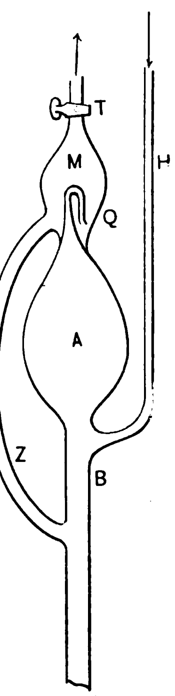


Fig. 29.

Siemens's Pump. (First Form.)

head being broken off by violent uprushes of mercury in the large bulb. Guglielmo[4] ingeniously connected the closed top of the collecting vessel (into which the exit tube discharged air and mercury) with the closed top of the supply vessel, so that as the latter was raised, and the mercury ran out of it, the air-pressure upon the lower end of the barometric column in F was automatically lessened. Improved forms of overhead tube were suggested by von Helmholtz[5] and by Schuller,[6] and a very similar device was used by the writer in 1882 to connect a glow lamp to the Lane-Fox pump by merely sealing it to the top of a long barometric tube, which slipped on over the top of the open overhead tube—or of a tube connected with it—and dipped into an external ring of mercury in a cup forming a barometric air-tight trap. Neesen[7] designed a double-acting pump on this plan, with two pump-heads, and two fall-tubes, the mercury being mechanically driven alternately from one pump to the other by a piston working in a cylinder. The model has not yet been actually constructed.

Other improvements have been made in detail by Couttolene,[8] who drives the air into a partially exhausted space, by Diakonoff,[9] by Bessel-Hagen,[10] and by Karavodine.[11] The latter interposes between the top of the pump-head and the exit-tube, F, a small chamber closed at the bottom by a valve consisting only of mercury standing over a capillary orifice, exactly resembling that previously described by Schuller, figure 20. This has the result of causing the last portions of residual air to be expelled into a space containing a moderately perfect vacuum. This is a decided improvement. For, as was pointed out with respect to the Sprengel pump, the air carried down the narrow fall-tube is necessarily compressed in order to drive it down against atmospheric pressure, and bubbles or films remain adherent to the glass.

In some modern modifications this is to a very large extent obviated, by the device of so bending the eject-tube or fall-tube, that the air expelled from the pump-head need only descend a very few centimeters down the tube before it enters a chamber that is partially exhausted. In short, if by any device—whether by placing it at the top of a fall-tube or by applying a good mechanical pump—a moderately good exhaustion can be maintained with a chamber such as that marked M, and this chamber is joined to the pump-head by a descending fall-tube; the length of this fall-tube need not exceed the height of a column of mercury representing the difference of pressures between the two chambers. In the diagrams that follow, such a shortened fall-tube is marked Q; it may be regarded as a sort of siphon air-trap. Such an arrangement has been independently devised by several persons. It was patented by Siemens and Halske[12] in Germany, in 1884. Figure 29 shows the device as originally designed. The pump-head terminates in a capillary tube, which turns over into a pool of mercury in the base of the upper chamber, M, into which the residual air is driven with a very slight compression. When a certain amount has thus been collected, it is expelled by further raising the mercury and opening the top tap, T, which is otherwise kept closed. A wider tube, Z, which should be usually closed by a tap, serves to return to the pump shaft the mercury which may have been driven over into M. A later form of this pump, depicted in figure 30, is used in Siemens and Halske's lamp factory in Berlin.

A similar device was suggested by Sundell,[13] who has further improved the arrangements at the bottom of fall-tube, so as to allow of other gases being admitted to the pump. Some of Neesen's pumps, and that used in the Weston lamp factory in Newark, also have this device; but these belong to the sub-class of shortened pumps, and are described below.

Mr. Swinburne,[14] who has had extensive experience with pumps of several kinds, has described a form in which this principle is applied. Swinburne's first form, though provided like Toepler's, with a fall-tube, had also an automatic valve above the pump-head. Figure 31, taken from Swinburne's paper in the *Electrician*, shows this valve situated above a small cavity, C, separated from the pump-head by a constriction, the object of which is to prevent the glass bottom of the valve being broken by the sudden rise of the mercury. The eject chamber, E, is connected through a tap, L, to a horizontal pipe, marked F in this cut. This pipe which runs along a whole range of pumps in the pump-room of the lamp factory is mechanically exhausted, and the use of the tap, L, is to start the action of the pumps. After this the action is kept going by a three-way tap (here marked K) which connects the cavity above the mercury in the supply vessel alternately with

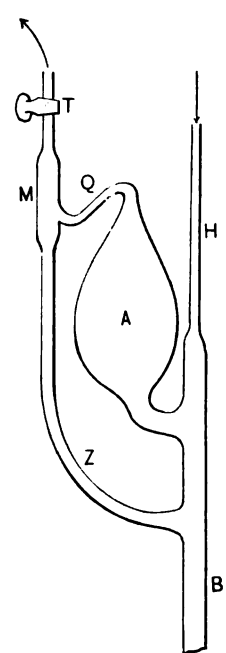


Fig. 30.

Siemens's Pump. (Factory Form.)

the atmosphere and a supply of compressed air. In a later form, Swinburne's pump has a siphon mercury-trap between the pump-head and the automatic valve above it. When the exhaustion

1. Read before the Society of Arts, London (Eng.), Wednesday, Nov. 23, 1887.
2. "Wiedemann." "Wied. Ann.," x., 206, 1880.
3. Neesen. See below.
4. Guglielmo. "Wied. Beibl." v., 16, 1881.
5. Von Helmholtz. See Bessel-Hagen, "Wied. Ann.," xii., 429, 1881.
6. Schuller. "Wied. Ann.," xiii., 533, 1881.
7. Neesen. "Wied. Ann.," xi., 522, 1880.
8. Couttolene. "Comptes Rendus," xci., 920, 1880.
9. Diakonoff. See Karavodine,
10. Bessel-Hagen, *loc cit.*
11. Karavodine. "Journal de Physique," S. II., vol. ii., 558, 1883.
12. Siemens and Halske. D. R. Patent, 28,579, Jan., 1884. For the accompanying sketches of the pumps, the writer is indebted to Herr von Hefner Alteneck.
13. Sundell. "Wied. Beibl.," ix., 193. 1885.
14. Swinburne. The *Electrician*, xix., pp. 51, 71, 117, and 158, 1887; a series of papers giving a summary of valuable experience in exhausting glow lamps.

has been carried far enough, the mercury is lowered and raised some 10 or 20 times, just so far as to drive the residual air through the mercurial syphon, which will then show a small back pressure —perhaps of only one or two centimeters. If the volume of the pump-head is many times as great as that of the cavity beyond the mercury-trap, and if there be a fairly good vacuum beyond the trap, it is obvious that a back pressure of one or two centimeters as the result of 20 strokes may mean a very high degree of exhaustion. Swinburne remarks that the bore of the siphon tube used as a trap must be not larger in the descending part than in the part that ascends to the supplementary chamber.

CLASS III*a*.—SHORTENED UPWARD AND DOWNWARD-DRIVING PUMPS.

Swinburne's pump just described might, if worked intermittently with an exhausting instead of a compressing pump, be transferred to the category of shortened pumps.

Probably the more perfect of pumps in this class is that of Professor F. Neesen,[1] of Berlin. This indefatigable worker has introduced, from time to time, several improvements. As mentioned above, he introduced the side-tube, N, in 1878, and designed a double-acting Toepler pump in 1880. Independently of Mitscherlich, he introduced the automatic valve above the pump-head. In 1882 he was already employing the recurved siphon trap, Q, between the pump-head and the second chamber, M. His complete pump, as constructed in 1887, is shown in figure 33. The lower portion is constructed on Robinson's plan, airtight connections being formed at the three necks of the bottle, L, by the use of coned steel collars, that are cemented to the three tubes, and fit to coned adapters, cemented to the three necks. Steel screw caps clamp down the conical collars into their respective seats. The tube, Y, is put into alternate communication with the atmosphere, and with a good mechanical air-pump, so as to raise and lower the mercury alternately, in the pump-head, A. There is an automatic valve, U, in the exhaust-tube, which leads up to the drying flask and to the lamp or other vessel that is to be exhausted. This valve, which is shown enlarged in figure 34, is made somewhat on the plan of Schuller, described above, with a small glass disc about two centimeters in diameter, cut from thin plate-glass, which, as the mercury rises under it, is pressed up against a flat flange, fashioned on the lower end of the upper tube. It works in a manner that leaves nothing to be desired. This pump is further provided with a chamber, M, and a siphon-trap, Q, down which the residual air from the pump-head is expelled into a moderately perfect vacuum.

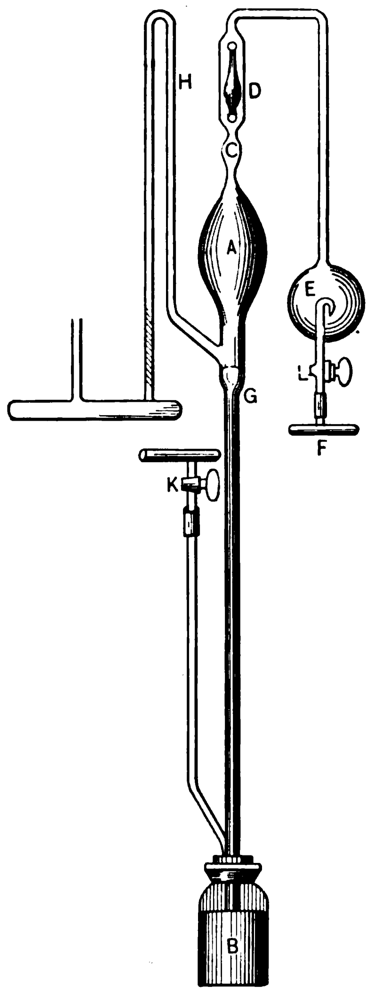


Fig. 31.

[2] Swinburne's Pump.

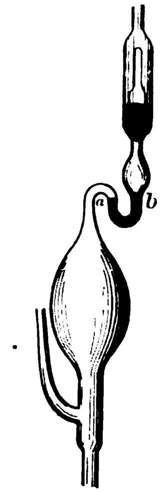


Fig. 32.

Swinburne's Pump. (Later form.)

Another very interesting and extraordinary pump belonging to this class is that of P. Clerc,[3] depicted in figure 35. The apparatus shown is connected by a flexible rubber tube to a mechanical pump capable of giving a moderately perfect vacuum. The apparatus consists of a disc of wood, round the periphery of which is fixed a glass tube, closed in itself, but provided with a

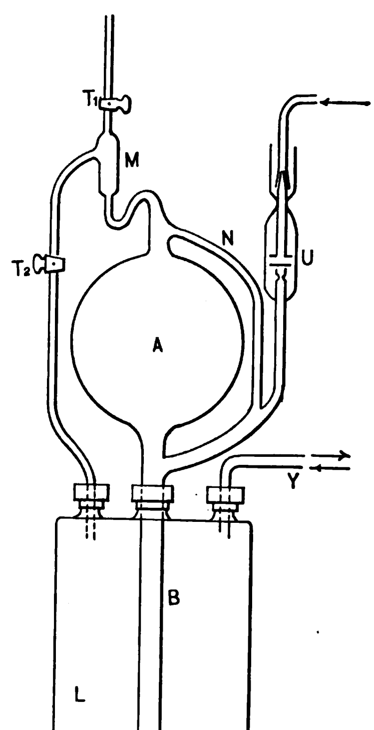


Fig. 33.

Neesen's Pump.

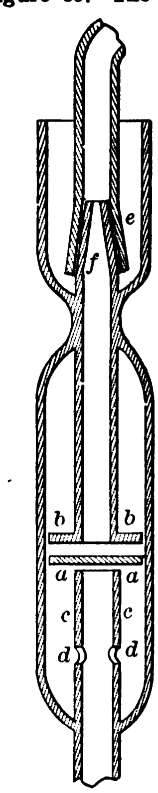


Fig. 34.

Form of 1887.

1. This figure is kindly lent by the editor of the *Electrician*.

2. Neesen. "Wied. Ann," iii. 608, 1878 *ib.*, xi., 522, 1880; *ib.*, xiii., 384, 1881; "Zeitschr. für Instrumentenkunde," ii., 287, 1882; *ib.*, iii. 245, 1883; also, "Wied. Beibl.," vii., 651, 1883. Figures 33 and 34 are from sketches kindly furnished by Professor Neesen.

3. Clerc. "Dingler's Polytechnisches Journal," cclxii., Part II., 1886; also "Zeitschrift für Instrumentenkunde," vi., 403, 1886; and D. R. P. 36,447, of 1885.

U-shaped bend to serve as an air-trap. At one side of this trap rises a short branch tube to which the lamp that is to be exhausted is sealed; at the other a similar branch tube leads to a bulb connected through a tap to the auxiliary pump. Enough mercury is placed in the tube to occupy about a quarter of the circumference and fill the trap. The whole apparatus is mounted obliquely upon another disc of wood, in such a way that it can be rolled round on its periphery by means of a projecting central handle. A preliminary exhaustion having been attained, the tap is closed and the apparatus is rolled around. The mercury in the tube sweeps the air before it into the bulb, and, passing into the trap again, emerges to push a fresh quantity from the lamp in front of it, leaving behind every time in the trap a sufficient quantity of mercury to balance the difference of pressure between the bulb and the lamp. The quantity of mercury required for this apparatus cannot exceed a few cubic centimeters at the most.

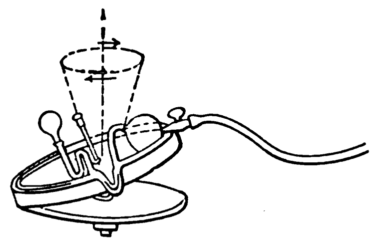


Fig. 35.

Clerc's Pump.

Figure 36[1] represents the pump used in the lamp factory of Mr. Weston, at Newark, New Jersey. The second chamber, M, connected with the pump-head by the siphon-tube, Q, will at once be recognized, as also the automatic valve, U, in the exhaust tube. The mercury in the supply-vessel, S, is raised and lowered by alternately connecting the upper part of the vessel through the three-way tap, Y, with a mechanical exhaust pump, and with the atmosphere. The top tap is only used when the chamber, M, has to be put into communication with the mechanical pump; the other taps are safety taps, not used during the working of the pump. The tap between the lamps and the valve, U, is worse than useless.

CLASS IV.—COMBINATION PUMPS.

It has been suggested by Edison[2] and by Böhm[3] to combine a Geissler pump with a Sprengel pump in the endeavor to obtain a more perfect result. This method of combination which consists merely in sealing the exhaust tubes of each pump together and to the lamp cannot be commended. If the Geissler exhausts more perfectly than the Sprengel, or *vice versa*, then the other pump is useless. A much more hopeful combination has been suggested by Mr. J. T. Bottomley,[4] who proposes to utilize a Geissler arrangement to exhaust the chamber into which the foot of the fall-tube of the Sprengel is led, thus putting the two pumps into series.

CLASS V.—INJECTOR PUMPS.

There are a few pumps depending for their action upon the principle of the injector, the degree to which they exhaust depending upon the velocity of efflux of mercury from an orifice, as in the original injector of Hauksbee. The earliest of these were designed by Cavarra[5] and Plateau.[6] Another form, exhibited in 1876 at South Kensington, was invented by Professor von Feilitzsch,[7] in which two cylinders fitted with pistons, worked by cranks, drove a mercury blast through suitable jets and drew in air, so creating a vacuum. It exhausted down to a pressure of one millimeter, or about 1,300 millionths of an atmosphere.

Several other injection pumps of the centrifugal species were described by de Romilly[8] in 1881, one of them being designated as a *pnéole*. Nothing is known to the writer as to its performance.

1. For this sketch the writer is indebted to Professor G. Forbes.

2. Edison. "Scribner's Monthly Magazine," Feb. 1880, p. 538; "English Mechanic," xxxii. 117, 1880; see also Urbanitzky, "Das Elektrische Licht," 1883, p. 56.

3. Böhm. See Merling's "Elektrische Beleuchtung," p. 394, or Urbanitzky, *op. cit.* p. 63.

4. Bottomley. "Rep. Brit. Assoc.," 1886, Birmingham Meeting, p. 519.

5. Cavarra. "Comptes Rendus." 1843.

6. Plateau. Hervorbringung eines Vacuums mittelst der Centrifugalkraft des Quecksilb s. "Pogg. Ann." 151. 1843.

7. Von Feilitzsch. Theorie und Construction einer hydrodynamischen Luftpumpe. Greifswald, 1876. See also "Mitth. des naturwiss. Ver. v. Neupommern und Rügen," ix., 1877 and Catalogue of Loan Collection of Scientific Apparatus (1876), p. 134.

8. F. de Romilly. "Journal de Physique," Ser. 1, vol. x., 303, 1881; Ser. 2, vol. iv., 366, 1885.

CLASS VI.—MECHANICAL MERCURIAL PUMPS.

Only one pump is known to the writer as coming definitely within this category; and this is a pump designed and constructed by Mr. J. Wimshurst, and of which no account has hitherto been published. It consists of an endless chain of little steel buckets, which pass up one barometric column and down another, within steel tubes containing mercury. Below, they enter a mercury bath, where they pass under two square pulleys, rising over a higher driving pulley between the two. The buckets as they descend, mouth downwards, carry down air from above the top of the barometric column, and discharge themselves as they come up in the mercury bath. Owing to the fact that it has hitherto been found necessary to employ oil as a lubricant, the power of this highly ingenious apparatus to produce a vacuum is limited.

There are a few pumps concerning which the writer has not been able to obtain information, including those of Diakonoff, Neveux, Pfluger, and Southby, which are known to him by name only.

RESULTS.

The results that have so far been obtained by various pumps may be briefly tabulated as follows: the vacua produced being specified both in millimeters and in millionths of one atmosphere.

If Rood's method of measurement be correct, the results attained by him are very remarkable.

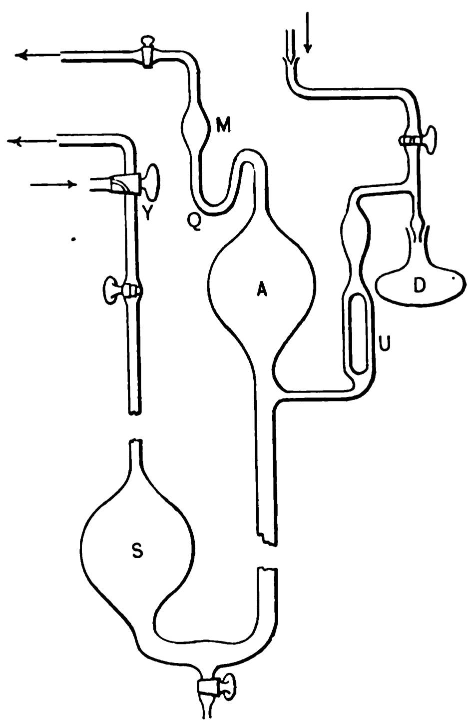


Fig. 36.

Weston's Pump.

Authority.	Nature of pump.	Pressure in millimeters of mercury.	Pressure in millionths of one atmosphere.
Crookes.....	Improved Sprengel (maximum result)............	0.000 046	$\frac{1}{17}$
Gimingham.	Single-fall Sprengel, 1.1 millim. diam...........	0.000 51	$\frac{2}{3}$
" .	Five-fall Sprengel..........	0.000 006	$\frac{1}{125}$
Rood........	Plain Sprengel	0.000 152	$\frac{1}{5}$
"	Rood's Sprengel, heated....	0.000 002	$\frac{1}{385}$
Bessel-Hagen	Old Geissler, after 25 strokes	0.110	145
"	New Geissler (2 taps), after ditto (average)...........	0.008 5	11
"	New Geissler (2 taps), maximum result)............	0.008 2	$10\frac{1}{4}$
"	Old Toepler, after 5 strokes	0.007 5	10
"	" after 5 more..	0.006 4	8
"	Modified Toepler (average)	0.000 012	$\frac{1}{63}$
"	" " (maximum result)	0.000 008	$\frac{1}{95}$

CONCLUSION.

On comparing the experience of various workers, it seems as if the best class of pump for the production of such vacua as are required for lamps is the third class, as modified so as to drive the air up the pump head and down a simple short barometric trap into an already partially exhausted chamber. No one appears to have yet tried a shortened Sprengel with a crook in the fall-tube. The writer offers it as a suggestion. Further, if the experiments of Rood are worth anything, they indicate that an immense advantage is gained by working with pumps heated up above the boiling point of water. The "adsorption" of gases and vapors against the surfaces of glass and mercury in the working parts of the pump is certainly much less hot than cold. Why should not all pumps be so constructed as to enable this method to be adopted? Since much seems to depend on the purity of the mercury, why should not the mercury be distilled direct into the pump? Whenever cements are used, why should not some plastic inorganic substance, such as chloride of lead or tungstate of lead be employed, instead of resin, pitch, or other organic body, which will give off vapors. Lastly, if the device of exhausting into an already fairly well exhausted chamber so greatly improves the degree of rarefaction attainable, why should we not carry this process one or two stages further, and relay a series of pumps one working into the other? Such a process would resemble those processes of successive operations which have been called "Pattinsonization;" and it is possible that it might yield results surpassing anything yet attained.

In surveying the literature of the mercurial air-pump one cannot but be struck with the immense number of workers who have contributed to the invention and the number of details that have been independently reinvented by different individuals. The literature of the mercurial pump affords, indeed, a striking proof of the fact that inventions grow rather than are made. The invention is essentially the product of the age in which it appears, a necessary consequence of the inventions and discoveries that have preceded it. The scientific method of investigating historical events has shown us how false, how childish, is the "great man" theory of history, which was taught—and alas! is taught still—to us at school. But if the great man theory of history is fallacious, so is also the great man theory of inventions. There were steam engines before Watt, locomotives before Stephenson, telegraphs before Wheatstone, telephones before Bell, gas engines before Otto. It may be that occasionally an inventor strikes upon a valuable or useful improvement; it is exceedingly rare for an absolutely original invention to be sufficiently perfect to be of immediate use. Of the essential insufficiency of the great man theory of inventions, the literature of the mercurial air-pump affords a most striking proof.

The investigation of this literature, which has long occupied the writer, has been a fascinating pursuit, partly because of its unexpected richness, partly on account of the fascination of the subject. Everyone who has worked with mercurial air pumps must acknowledge to a kind of fascination in watching the ebb and flow of the liquid metal, and in speculating on the nature of the actions that go on in the vacuous spaces. It was, perhaps, with some such sense that Hauksbee, after describing one of his physico-mechanical experiments, wrote these words :—"Such a dense and polite Body is Mercury; such a subtle Mover is Air; and such an apt Repository is an Exhausted Receiver."

POINTERS.

.... WHAT difference does it make to a gas company whether the money expended for improvement account be for coal benches, holders and mains, or for dynamos, boilers and wire?—*Thomas Wood.*

.... IF there is any money to be made in the electric lighting business by others, there is still more in it for the gas companies. —*Thomas Wood.*

.... THE gas companies had better take up electric lighting as speedily as possible.—*Joseph Gwynne.*

.... No mistake should be made in regard to the staying qualities of the electric light. It has come to stay, and will stay in spite of all efforts or wishes to the contrary.—*Geo. Shepard Page.*

.... CONSUMERS will have the electric light if it costs twice as much as gas. It is good policy for the gas companies to recognize the fact and govern themselves accordingly.—*Geo. Shepard Page.*

.... WHILE we are gas men, we are really suppliers of light, and should be prepared at all times to furnish any kind required. —*Eugene Printz.*

.... THE introduction of an incandescent plant into the business district of a town, means the loss of the gas consumption of at least a five foot burner for each incandescent lamp used.—*F. W. Day.*

.... IT would seem that gas companies are much more favorably situated for furnishing both arc and incandescent lights or electric current than anybody else.—*F. W. Day.*

SIR WILLIAM THOMSON'S NEW STANDARD ELECTRICAL MEASURING INSTRUMENTS.[1]

BY J. A. FLEMING.

FOR the last six years, Sir William Thomson has been engaged in developing and perfecting a complete series of instruments for the measurement of electric currents. Beginning with the now well-known graded galvanometers, he has finally accomplished the task of providing a connected group of instruments, which may be broadly classified into three divisions: (1) Standard direct reading electric current balances; (2) magnetostatic galvanometers or lamp counters; (3) marine and engine room voltmeters. The standard direct reading electric current balances are standard instruments, in which every source of possible error arising from the use of permanent magnets or soft iron is eliminated, and the operation of these instruments consists entirely in weighing, by means of standard weights, the attraction or repulsion between movable and fixed coils of wire conveying electric currents. These standard current balances may be said to be modifications of the electro-dynamometer, which was first described by Weber in his "Electro-dynamische Maasbestimmungen" (Leipsic, 1846). The foundation of the electro-dynamometer was, however, laid long previously. On 25th September, 1820, André Marie Ampère announced to the Royal Academy of Sciences, in France, that he had discovered the existence of forces of attraction and repulsion between conductors of non-magnetic material traversed by electric currents. The experiments of Ampère and the elaborate researches of Weber (W. Weber, "Electro-dynamische Maasbestimmungen, Thl. I., s. 10, 1846, Auszug in Pogg Annal, Bd. lxxiii., s. 193), established the fact that if there be a fixed and a movable conductor in the neighborhood of each other, traversed by the same electric current, there will in general be a mechanical stress brought into existence, which will tend to displace the movable conductor, and bring it into a position relatively to the fixed conductor in which the mechanical stress between them is zero. The mutual force or stress between these mutually influencing portions of the same circuit is, in any given position, proportional to the square of the strength of the current traversing the two portions of the circuit. In Sir William Thomson's standard instrument this stress is measured by comparing it with or balancing it against the weight of certain standard masses; in other words, the electro-dynamic stress is compared with the gravitation stress on a given mass.

The great difficulty which has hitherto presented itself to all who have attempted to design instruments on the electro-dynamometer principle for any but very small currents has been that of getting the current into and out of the movable conductor. The device on which most experimentalists have fallen back is that adopted by Ampère himself, viz., to use mercury cups as a means of constructing a flexible and conducting joint. The use of mercury is open to many objections. The surface gradually becomes oxidized, the cups must be filled and emptied each time, the instrument has to be transported, and the joint with impure mercury is by no means exceedingly flexible. The great achievement in these instruments has been, first, the invention of a joint or electric coupling which is excessively flexible, and at the same time capable of being constructed so as to carry with safety any current desired. This has been accomplished by the introduction of a device which may be called a metallic ligament. The general principle of its construction, and the mode of rendering a circuit freely movable, yet accessible to a large current, may be described as follows: Let A A (figure 2) be a pair of semi-cylindrical fixed trunnions, which are carried on some form of supporting frame, and held with the flat sides downwards. Let B B, be two similar trunnions, which project out from the sides of two strips, connecting together a pair of rings, C C. The pair of rings and the connecting strips constitute the circuit which is to be rendered movable. A current entering by the trunnion + B flows round the two halves of the circuit, as shown by the arrows, and emerges at the trunnion — B. In figures 2 and 3, the current is shown dividing round the two rings; but we should explain here that this has been done by an oversight. The circuit should be shown so that the current goes round both rings in series, in figure of 8 fashion. This is the case in all but the kilo- and hekto-ampere balances, in which the current divides round the ring. To the upper surface of the upper trunnion are soldered a very large number of exceedingly fine copper wires (No. 60 B. W. G.), which are laid close together. These wires are also soldered to the under surface of the lower trunnion. The movable circuit C C, thus hangs from the upper trunnion by two ligaments, which appear like thin strips, but which are really composed of an immense number of very fine wires. In figure 2, these ligaments are intentionally drawn much longer in proportion to the rest of the figure than they really are in the instrument, the object being to render the mode of suspension clear. This method of suspension enables the conductor C C, to vibrate freely like a balance by a motion which is partly a bending of the flexible ligaments, and partly a sort of rolling and unrolling of the lower trunnion on the ligament attached to it. By this ingenious method not only can a heavy

1. Reprinted from *Industries.*

copper conducting circuit of the shape shown be suspended as freely as the beam of a good balance, but at the same time a very large current density can be permitted in the flexible ligament, since its great radiating surface, and the freedom with which heat is taken out of it by conduction into the mass of the trunnions, allows a proportionately very large current to be transmitted. If, then, the trunnions A and B are the electrodes, the method above described affords the means of passing a very large current into the circuit C C, which yet at the same time retains within certain narrow limits great freedom of movement. Let such a suspended conductor be arranged so as to have a circular conducting circuit of annular form, briefly called an ampere ring, placed above and below each of the movable rings of the balanced arm. Let the connections be made as shown diagrammatically in figure 3, in which it will be seen that the current entering by the + electrode flows in series through all four fixed ampere rings F, and in parallel through the two movable ampere rings M. An examination of the direction of current flow in each ring will then show that, in consequence of Ampère's law (parallel currents in same direction attract, in opposite direction repel), forces of attraction and repulsion will be brought into play between each fixed ring and the movable rings, which tend to lift one ring, M, and depress the other, and tilt over the balance arm to which they are attached. The amperian forces thus exert a couple on the movable part. To bring back the movable part to its initial position, which we may suppose to be half way between each fixed ring, an equal and opposite mechanical couple must be applied. We shall in what follows call the movable part of the conducting circuit the balance coils, and the other portion of the circuit the fixed coils. The operation of weighing an electric current consists, therefore, in (figure 4). On the base board of the instrument, and just underneath the shelf on which the weight slides, is placed a little metal block, which carries a stout vertical wire extending a little above the shelf carried on the balanced beam. From the top of this wire is carried a pendant wire, which hangs down through a notch in the weight which slides on the shelf. This block, carrying the pendant, is pulled along the railway by a silk cord. When pulled it drags with it the weight on the shelf; but when the string is released the pendant returns to its vertical position and disengages itself automatically from the weight, leaving the balance free to tilt according to the direction of the forces acting upon it. By this means the weight can be shifted along until a balance is obtained, whilst at the same time the whole balance is covered with a glass case to protect it from currents of air. With each current balance three sliding weights and three corresponding counterpoises are provided, the weights being in the ratio of 1, 4, 16. Thus if with the ampere balance the lightest weight on the sliding tray in a certain position corresponds to a current of half an ampere through the instrument, the next weight at the same place corresponds to one ampere, and with the heaviest weight on it the current is two amperes. The upper edge of the shelf on which the weights slide is graduated into equal divisions, and the weight is provided with a sharp tongue of metal, in order that its position on the shelf may be readily and accurately determined. For the purpose of avoiding continual reference to square root tables, another fixed scale is placed behind the shelf, called the inspectional scale. On the upper edge of the shelf, along which the graduations are made, a small notch is cut at those divisions whose numerical denominations are exact squares; thus corresponding to divisions 1, 4, 9, 16, 25, 36, &c., on the scale en-

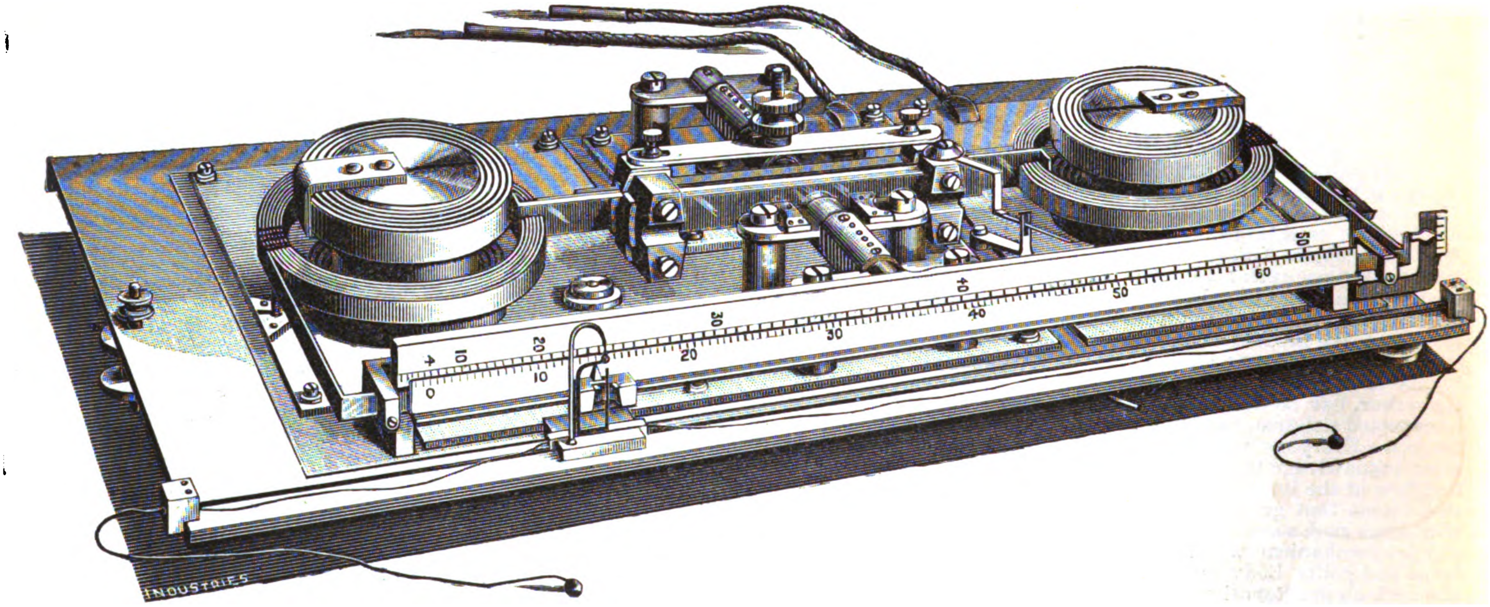


Fig. 1.

bringing first of all the balance coils into a definite sighted position between the fixed coils, then passing the current and bringing back the balance coils into the sighted position against the displacing electro-dynamic forces by applying to the balanced part a couple produced by a standard weight. The restoring couple is applied as follows: Attached to the balanced part or movable portion is a stiff metal bar, turned up at the bottom edge so as to form a sort of long shelf. This shelf or tray extends the whole length of the movable beam, and moves or tilts with it when the balanced part is displaced (see figure 1). At one end of the balanced part, at the extreme right of our illustration, is a small V shaped tray, in which a weight is placed. A standard weight is then placed at the opposite end of the shelf. This weight is of such form as to slide along the shelf easily (see figure 4). When placed at the zero position on the shelf it exactly balances the counterpoise in the V trough, and the balanced part should be in equilibrium when no current is passing. If it is not so, then a small adjustment can be made by means of a metal flange on the beam (figure 1), similar to that on a gravimetric balance. If the sliding weight on the shelf is moved along towards the middle the equilibrium is disturbed and a couple brought to bear upon the balanced part, which is proportional to the displacement of the sliding weight from its zero position. If a current is passed through the circuit, and the sliding weight displaced so as to restore the balance to its sighted position, the current strength is proportional to the square root of the distance by which the sliding weight has to be shifted in order to restore equilibrium. The shifting of this weight is performed by a very ingenious piece of mechanism, which will be understood from the enlarged view graved on the shelf are cut little notches in its upper edge. The inspectional scale is fixed close behind this, and yet not touching, and at those points on it exactly behind the notches are engraved numbers which are twice the square roots of the corresponding numbers on the shelf; thus corresponding to 1, 4, 9, 16, 25, &c., on the shelf the numbers 2, 4, 6, 8, &c., are engraved on the inspectional scale. Since the current passing through the balance when equilibrium is obtained with a given weight is proportional to the square root of the couple due to this weight upon the balance, it follows that the current strength when equilibrium is obtained is proportional to the product of the square roots of the weight used and of the distance of this weight from its zero position; but the inspectional scale is so graduated as to show at a glance the square root of the distance of the weight from its zero position, and hence the numbers on the inspectional scale indicate half amperes, amperes, or double amperes, according to the weight used.

The fixed inspectional scale shows approximately enough for many purposes the strength of the current; the notches in the top of the aluminum sliding scale or shelf show the precise position of the weight corresponding to each of the numbered divisions on the inspectional scale, and practically annuls error of parallax due to position of the eye. When the pointer on the weight is not exactly below one of the notches corresponding to integral divisions of the inspectional scale, the proportion of the space on each side to the space between two divisions may be estimated inspectionally with accuracy enough for all practical purposes. Thus, we may readily read off 34.2 or 34.7 by estimation, with little chance of being wrong by .1 in the decimal place. But when the utmost

accuracy is required, the reading on the fine scale of equal divisions must be taken, and the strength of the current estimated by aid of a table of square roots supplied with each instrument.

These general principles being understood, we proceed to describe the details of the several types of instruments adapted for

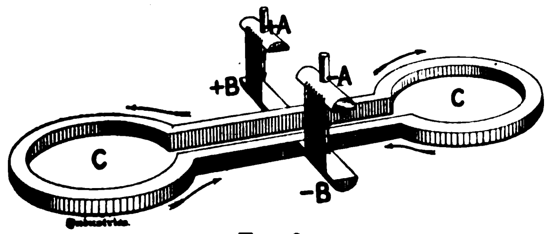


FIG. 2.

various ranges of useful measurement. The range of each instrument is from 1 to 50 times the smallest current for which its sensibility suffices. The ranges of the different types of instrument regularly made are:—

The Centi-ampere	balance	from	1 to	50 centi-amperes
" Deci-ampere	"	"	1 to	50 deci-amperes
" Ampere	"	"	½ to	25 amperes
" Deka-ampere	"	"	2 to	100 "
" Hekto-ampere	"	"	10 to	500 "
" Kilo-ampere	"	"	50 to 2,500	"

Figure 5, shows the general appearance of the centi-ampere, deci-ampere, ampere, and deka-ampere balances. In these instruments the outer diameter of the fixed coils is slightly greater, and the inner diameter less than those of the movable rings attached to the balance arms. The position of the movable rings when in equilibrium and equi-distant from the fixed ones above and below it, is a position of minimum force, and the sighted position for the sake of stability is above it at one end of the beam and below it at the other, in each case being nearer to the repelling than to the

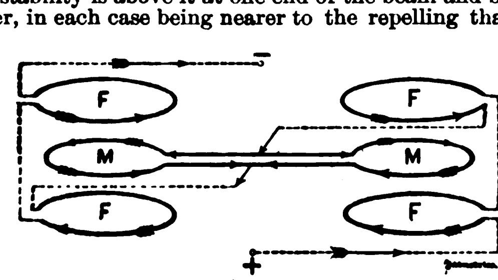


FIG. 3.

attracting ring by such an amount as to give about $\frac{2}{10}$ per cent. more than the minimum force. In order to adapt these balances for alternating currents, a special mode of arranging the conducting circuit has to be adopted. In the balances intended for alternate currents (which may be used also for direct currents) of from 5 amperes to 250 amperes, the main current through each circle, whether consisting of one turn or of more than one turn, is carried by a wire rope, of which each component strand is insulated by silk covering or otherwise from its neighbor, in order to prevent the inductive action from altering the distribution of the currents across the transverse section of the conductor; whilst to avoid induced currents in these parts the coil frames and base board are

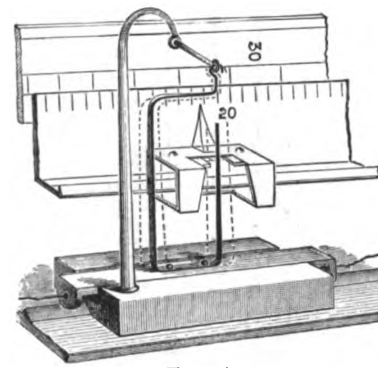


FIG. 4.

constructed of slate. The hekto-ampere and kilo-ampere balances are slightly different in arrangement from the foregoing. In these the whole current to be measured is passed through a single fixed ring and then divides through the two halves of a movable ring, which are urged, one up and the other down, by the resulting amperian force. The largest balance yet made is one for measuring currents up to 2,500 amperes, constructed for Messrs. Paterson and Cooper. The centi-ampere balance (figure 5) is provided with a thermometer to test the temperature of its coils, and it may be used as a voltmeter when provided with platinoid resistance coils, which make it available for the measurement of potential difference from 10 up to 200 volts or more.

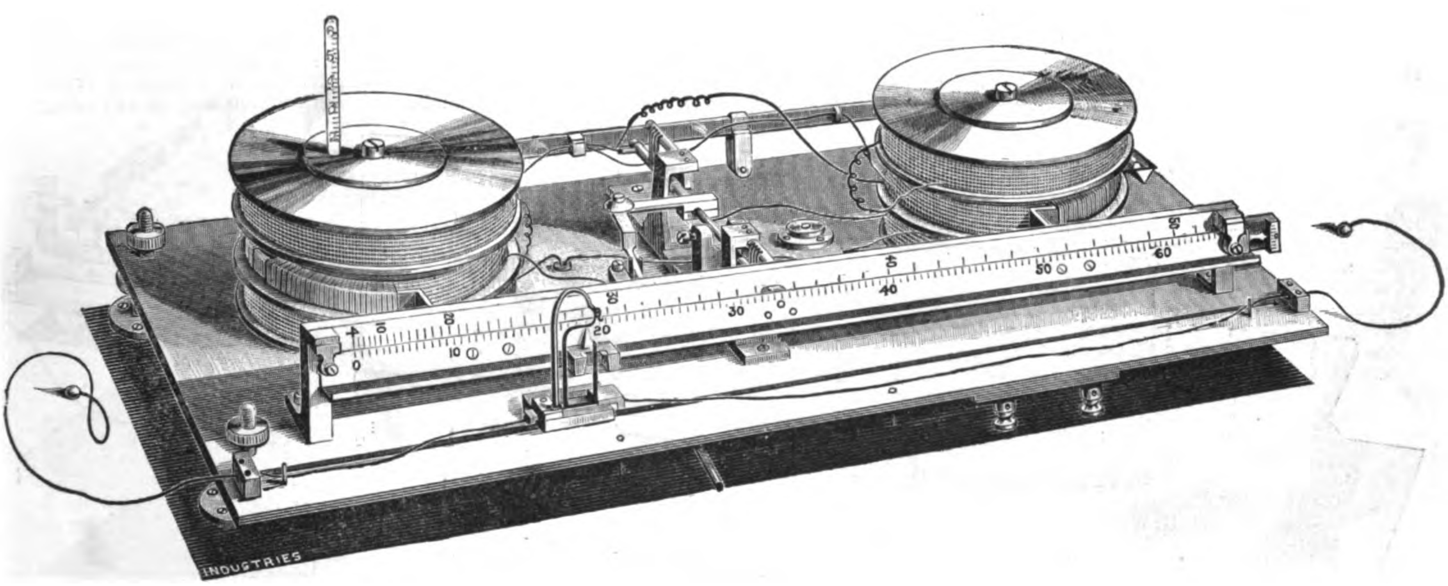


FIG. 5.

The direct reading engine room voltmeter is an instrument based upon the same principle, but which indicates potential difference between certain limits without the performance of any operation of weighing. This inspectional voltmeter (figure 7) consists of a fixed platinoid resistance, which is in series, with a fixed and movable ampere ring. On the base board of the instrument is fixed horizontally, a single coil of highly insulated copper wire. Over this, and suspended parallel to it, is a movable coil, carried at the end of an aluminum rectangular frame, which is suspended by ligaments near the opposite extremity. The weight of the coil is counterbalanced by adjustable weights, so that its normal position is parallel to and a little removed from the fixed coil. When these three coils (viz., the platinoid resistance coil below the base board, the fixed coil, and the movable coil) are traversed by one and the same current, the electro-dynamic repulsion lifts the movable coil, and raises it slightly from the surface of the fixed coil, on which it rests when no current is passing. If the current through the coils is slightly increased, the movable coil is repelled a little more; and if it is diminished, it is repelled a little less. These small movements of the coil are multiplied by a lever, the long arm of which moves over a scale, and the short arm of which is connected by a stiff wire with the balance bar carrying the coil. The fixed and movable ampere rings are each composed of many

turns of fine insulated copper wire, having a total resistance of 100 ohms. The amount of added platinoid resistance depends on

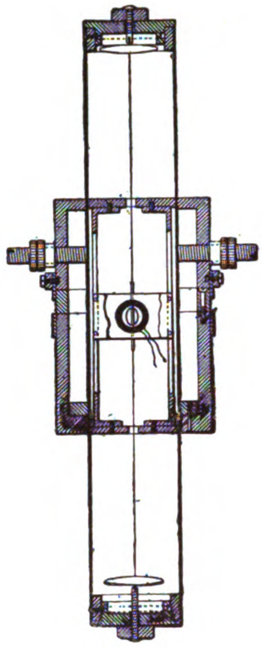


FIG. 6.

the potential to be measured in the ordinary use of the instrument. Thus for potentials of from 10 per cent. below, to 10 per cent.

marine voltmeter consists of a small oblate spheroid of iron, resembling a small round bean or flattened pea. It is attached to the middle of a platinoid wire, which passes through its equator, so that it is suspended with its equatorial plane vertical. If such an oblate is placed in a magnetic field, it will endeavor to place the plane of its equator in the direction of the lines of force of the field; and the couple required to hold it in any given position will depend upon the mass of the iron, and the form and strength of the field. In the marine voltmeter the magnetic field is created by a current circulating in a coil of copper wire in series with a set of platinoid resistance, variable according to the potential to be measured. The platinoid wire carrying the oblate is stretched by attaching it to the ends of a tubular support, whilst the oblate carries a pointer which moves over a dial. The magnetic field due to a current in the coil is a uniform field, and the zero portion of the oblate is, with its equatorial plane, inclined at an angle of about 45° to the lines of force. The platinoid wire bearing it is arranged so that its torsion tends to turn it into a position at right angles to the lines of force. This tendency is resisted by a stop against the needle, so placed that when no current, or any current less than 90 milliamperes is passing through the instrument, the needle remains at the end of the scale. When a current exceeding 90 milliamperes is passing through the instrument, the E. M. F. operates against the torsion, and turns the oblate into a definite position in the field. The position of the oblate is thus a measure of the current passing through the instrument, and hence of the potential difference at the terminals of the coils. When the mean potential difference to be measured is 100 volts, the platinoid resistance is adjusted to make up with the fine copper wire solenoid, the resistance of which is about 60 ohms, a total resistance of 1,000 ohms. Thus the direct reading of potential on the scale is in volts.

Another instrument for use in electric light installations is the adjustable magneto-static current meter and lamp counter. This instrument is a convenient modification of the well-known graded galvanometers. It is a direct reading galvanometer, and has certain advantages over the electric balances in portability, and in being direct reading through a continuous range of from 1 to 90 or 100 times its smallest current, which may be anything

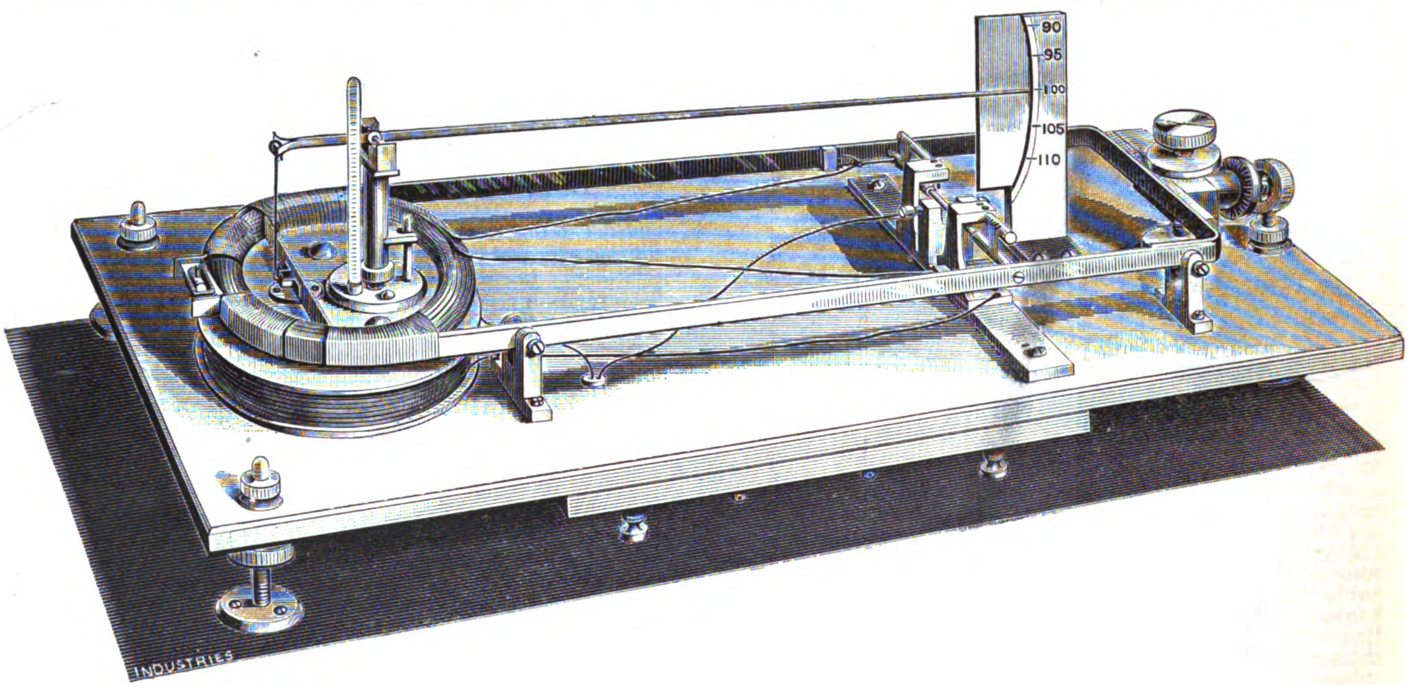


FIG. 7.

above 100 volts the platinoid resistance is 700 ohms. The scale is divided so as to indicate directly in volts. The instrument is specially designed for use as an engine room voltmeter, and indicates directly, within allowable limits, the excess or deficit of E. M. F. from the normal. Temperature error is annulled by providing a thermometer, placed in the coils, and a set of compensation weights. Four weights, corresponding to centigrade temperatures 15°, 20°, 25°, 30°, are supplied, and when the thermometer indicates any atmospheric temperature between these limits, the weight most nearly corresponding to that temperature is placed in the V trough attached to the end of the balance bar on the left. When not in use, the weights are kept in little receptacles marked with the temperature, so that no mistake can be made in seeing which is in use.

The marine voltmeter (see figure 6), is an instrument designed for use at sea. The foregoing engine room voltmeter, and the deci- and centi-ampere balances, are not suitable for this purpose, as the mass of the moving part of the balance is too great. The

from half a milliampere to one ampere, according to the number of turns in the coil supplied with the instruments. The general design of the instrument may be described as follows: Underneath a circular dial plate are fixed a pair of semi-circular coils, which may consist of many turns of wire or of a massive copper bar, according to the strength of the current to be measured. Centrally beneath the dial plate is a short glass tube, in which is suspended a circular disc of magnetized steel. The suspension of this disc is very ingenious. On the surface of the dial plate is fixed a piece of platinoid spring, and from this depends, by a short cocoon fibre, an aluminum needle, which is carried on the same vertical axis as the magnetized disc. If the cocoon fibre were attached to some rigid support any shaking of the instrument would be certain to break it; but suspended as it is from a yielding and flexible support, any jolt or shake causes the spring to yield sufficiently to let down the needle on to the dial plate, and so saves the cocoon fibre from fracture. Underneath the coils is attached a permanent magnet which creates the controll-

ing field. The instrument thus virtually consists of a galvanometer with a powerful controlling field, and in this respect it has all the disadvantages of this class of apparatus: in not being available for alternate currents, and in that the value of the deflections is dependent upon the permanence of a steel magnet. With a good quality of steel and a proper ageing of the magnet (by heating it several times in boiling water and cooling it again, and subjecting it to somewhat varied rough usage), a very nearly permanent condition is reached, and its magnetism will probably remain constant from year to year. Still it can never be relied upon as absolutely constant, and hence the magneto static instruments require from time to time to be re-adjusted by the aid of a balance instrument, the adjustment consisting in shifting the controlling magnet. The scale has 100 divisions, corresponding to equal differences of tangents of the angle between the magnetic axis of the needle and the electro-magnetic axis of the rings. The divisions may be numbered from 0 to 100, but for many purposes it is convenient to number them from 30, 20, or 10 on the left of zero, and from zero to 70, 80, or 90 on the right; because we have thus larger divisions in the neighborhood of the zero than when it is taken at the extreme left of the scale, and because it is sometimes convenient to measure small currents in the direction opposite to that of currents ordinarily measured. The scale being so divided that its divisions indicate equal increments of current through the coils, it is possible to set the magnet beneath the coils, so that the unit of current shall be within certain limits of what is desired. It may, for example, be one milliampere, one ampere, or a tenth of an ampere; or, more convenient still, it may be made equal to the average current through a lamp on the installation in connection with which the instrument is used. It becomes thus a lamp counter, and when put on the circuit shows at once the number of lamps in actual use at that instant. The

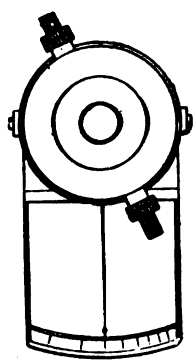


FIG. 8.

instrument may be made with such massive coils as to count lamps up to a thousand or more. When the instrument is used as a lamp counter, primary adjustment or re-adjustment can be performed at any time with great ease by turning the screw platform which bears the adjusting magnet, so as to raise it or lower it until it is found that the deviation from zero produced by the current of any number of lights shows a corresponding number on the scale of the instrument. With scales numbered from 1 to 90, any number of lamps within these limits can be directly counted by inspection; and for greater numbers of lights the instrument can be set to count by 5 or by 10, so that the attendant knows at any instant the load on his dynamo by simple inspection. The instrument must be, however, removed as far as convenient from the neighborhood of the dynamo, or else calibrated in the position in which it is to be used. The most convenient instrument of the complete series for an ordinary installation or workshop would be the deci-ampere balance, which measures from about one-tenth to five amperes, and a magneto-static galvanometer reading from 1 to 100 amperes. The magneto-static instrument can then at any time be re-adjusted by the aid of the balance. This is simply performed by placing the instruments in series on a circuit and passing a current of five amperes through them. The current should be adjusted until the deci-ampere balance indicates exactly five amperes, and then the magneto-static instrument set by raising or lowering its controlling magnet until its needle points exactly to five on the scale when the current is on, and to the zero of the scale when the current is off. At the last meeting of the British Association Sir William Thomson stated that the balance instruments have a sensibility of one-tenth per cent. over a range of something like 1 to 25 times the smallest current they are designed to read; but it should be understood that the balances may be used for double these currents with a slight sacrifice of accuracy.

POINTERS.

.... THE best storage battery is a ton of coal.—*Thomas A. Edison.*

ABSTRACTS AND EXTRACTS.

THE FUTURE PROSPECTS OF THE GAS INTERESTS.[1]

BY THOMAS WOOD.

THOSE who were in attendance at our Dayton meeting will perhaps recall the fact that the writer at that time strongly advocated gas companies taking hold of the electric light and running same in conjunction with their gas business; you will also recall the fact that the writer suggested also gas companies taking up the incandescent electric light and fuel gas. Since that time it has been demonstrated by several gas companies in this and other states that the electric arc system can be added with success, financially, to gas companies and with satisfaction to their patrons, and the writer derives great pleasure in hearing of so many companies who have left the narrow and beaten track of prejudice and are now walking in the broad road of progression.

It is not my intention to dwell upon arc lighting only long enough to state that after two years practical experience with the combination our company consider they have taken a right step in adopting it and that it is satisfactory in every respect. Other gas companies who have adopted the arc system can undoubtedly corroborate this with their experience. I would make this paper a continuation of the last one by taking up the incandescent electric system and fuel gas question. That both will be introduced into every city in the United States before long by someone, I have not a shadow of a doubt, and why? Simply because they are both desirable commodities in domestic economy and hygiene.

Please lay aside all prejudice and I will show you an ideal domestic burner for illumination purposes. Now what comprises an ideal burner for domestic use? In the first place, such a burner must not blacken our walls and ceilings, neither must it give off deleterious products of combustion; it must be a steady light and not subject to draughts; it must not give out heat in summer; it must not be possible for inflammable goods to ignite by coming in contact with it; it must be a light that will have no ill effect if by accident the key is left open; it must be a light that our country cousins cannot blow out; neither must it be one that requires dangerous matches to ignite it; and lastly it must be a fairly cheap light. Now, gentlemen, if you have thrown prejudice to the winds, perhaps you can recognize in this ideal burner the incandescent electric light for domestic use. Now, if this light is an ideal burner, who is going to prevent its adoption by the public? Gas companies cannot, and if they cannot, no one can; so in my mind the wisest course to pursue is to admit what we know to be true, and proceed at once to supply the demand, increase our revenue, push out into the suburbs of our cities, sell it as cheaply as possible, and don't let others come in and take away what rightly belongs to you. If there is any money to be made in the business by others there is still more in it for us.

For store purposes, where the hours of burning are defined, I think it better to abandon the meter system and fix a price per annum or month for each lamp, taking into consideration the hours of use as a basis for charges. For private dwellings this would not be practicable, and we would have to resort to meters, or perhaps fix upon a price for furnishing the current and have the consumer purchase the lamps when renewals were needed; in this way economy would cheapen the light to the consumer. Any method that will dispense with the meter, and still be satisfactory, will be the one to adopt.

I cannot understand how some gas companies who have the incandescent electric system as a competitor can console themselves with the fact that it is not injurious to their gas business, even taking it for granted they are still selling as much gas as before its advent. Is this a reason why they should make no effort to secure their old patronage? I think not, for it is human nature to secure a whole loaf in place of the half when it is possible to get it.

A gas company's revenues would certainly be increased by the step, and a dangerous rival made profitable.

I think it is a mistake to think that by and by the people will get back to gas; of course, some will, just as gas consumers sometimes go back to coal; but because a few give it up, don't let us deceive ourselves by thinking all will do so eventually, for the incandescent electric burner is bound to remain wherever it is now in use, and will find its way to the other places where it is not now in use. That's all very well to talk about, I hear someone say, but what are they going to do with our prior investment? To such I would say: Push that, to cheapen it to its lowest point, and urge its use for power and cook stoves until such time that you find yourselves able to supply gas for heating purposes of all kinds.

1. Read at the Fourth Annual Meeting of the Ohio Gas Light Association, Sandusky, O., March 22, 1888.

What difference does it make to a company whether the money expended for improvement account be for coal benches, holders and mains, or dynamos, boilers and wire? I fail to see the difference, and if improvements have to be made in both, so much the better; it shows a healthy demand for both branches, and should be promptly provided for.

If arc lighting is to be the light on our streets and the incandescent electric lights for our stores and dwellings, shall we draw our fires and stop making gas? This, to the writer, would be an absurd deduction. It is for us to take things we find in nature's laboratory and select the fittest articles for each special use, and it is reasonable to suppose that it will be only the fittest that will finally be a success. The arc light, so far as the writer has ascertained, has asserted pretty generally throughout the country its supremacy on our streets, and this, in spite of all opposition from gas companies, showing conclusively that it has gained its position by the force of demand for the fittest. Incandescent electric light is just as surely finding its position and field of usefulness and in its turn will assert its supremacy; and why? Because it has the qualifications called for in the public specifications. Some will assert that it is too expensive to come into general use, and also that it is not as reliable as gas. The first is no argument against it, for was not coal gas sold at exorbitant prices in its early day? It certainly is capable of being cheapened in the future, as gas has been, and this is one reason why gas companies should enter the business, as it is in their power to cheapen it.

As far as reliability is concerned that certainly seems the most serious weakness, but don't be alarmed on that score, for, duplicate machinery or storage batteries will eventually overcome this bugbear; and while discussing this subject don't let us forget that the breaking of a main or filling up of a drip, a flood or explosion, or even Jack Frost has often caused our customers to think that even gas is not very reliable.

I cannot understand what gives gas companies as a rule their prejudice against electric lighting, unless it be that they imagine the outcome to be idle gas mains and cold benches. This I think is all wrong. The largest unoccupied field to day is the fuel gas field, and who should step in and supply this demand? Could anyone do it as well as the present gas companies? We have our mains and services already laid; we have our holders, meters, and trained labor; most of us have also the necessary land to spare on which to erect generators.

Next to the fuel gas field I think I can see another field nearly as extensive, and that is the coal-oil field.

Please imagine the following picture, which is representative of the writer's belief of what a gas company will be in the near future—in fact so near in the future that before our next convention rolls around it will be a reality.

One set of officers, whose principal qualification shall be progressiveness, their duties to be divided between electric lighting of all kinds, including electric power, fuel gas for all purposes, including gas engines; also incandescent lights off fuel gas mains.

Now let us see what the plant will consist of: One set of mains for fuel gas, from which our patrons will draw all their fuel, and also light if they wish. Gas engines will be run economically with this gas. One set of meters only will be required.

There will be no coal gas benches. The generators of the future will be on the cupola style, feeding by gravitation from the top. Native coals in all probability will be sufficiently good to make gas of. One portion of the plant will be devoted to the dynamos and engines for furnishing the electric light. Where the coal gas benches now are will be boilers, or perhaps even these will be unnecessary if gas engines be used. If steam boilers be used, they will be fired with producer and gas; the boilers will become simply pressure regulators. The revenues of gas companies will be increased five-fold if not more, the consumer will get cheaper fuel, cheaper power and cheaper light.

Native coal fields will become more valuable, and we will not pay tribute to other states as heretofore. The change from illuminating coal gas to fuel gas will perhaps be a slow one, owing to the conservatism of gas companies and imperfected details, but eventually it will be brought about in spite of all obstacles. If a company is operated as pictured it will furnish arc lighting, incandescent electric lighting and electric motors, fuel gas, incandescent gas lighting and gas engines.

Gas will be made on a larger scale, with less dirt and nuisance and without that laboriousness now necessary. Valves, levers and push buttons will displace scoop, drawing book and wheelbarrow, and the employés will no longer be known as "gas house terriers," but will become elevated to a higher plane. The officers of the company will also, of necessity, have to be more active and alert, and the rule of thumb will be at a discount. Now let us see where the gas man will be who fails to occupy these new fields of pasture green.

He will, of course, go on making coal gas in the old way; he will still wrestle with stopped stand-pipes, steam-jet exhausters, naphthaline, and worry over how much a bushel of coke weighs. He will try to convince his customers that he knows better than they do what they want and that anything but his gas is of no account; he will also keep on cutting out items from the newspapers whenever he finds it recorded that an electric light somewhere failed to flicker.

He will still maintain that there is not a company in the country making anything out of electric lighting; and it is only a matter of time when some fellow slips into his town and noting things, works up an arc light company, captures the street lighting and some of our friend's best consumers. The price of gas is lowered, all kinds of patent gas burners are invented to recapture those lost consumers, a fight ensues, factions are made in the town, and the arc light company adds an incandescent plant to that of arc light and captures more of our friend's consumers, and, to clap the climax, another fellow comes along and proposes to supply fuel gas to the citizens, gets a franchise, puts in pipe service, and our friend wakes up some fine morning to find that what the electric light fellow has left him in the shape of lighting has been captured by the fellow with the fuel gas plant, who puts in the incandescent gas burners.

Evidence is cropping up all around us that tends towards this change. We find manufacturers of fine clay goods now making carbons for electric lighting; we also find gas fixture manufacturers now making and selling electric wire of all kinds, besides other apparatus connected with the electrical field. Manufacturers of meters have not yet devised a meter for measuring electrical currents, but, perhaps, it would pay them to devote a portion of their time in studying one out.

As far as the present meter business is concerned, I think if this transformation of the gas business is brought about that the demand for gas meters would be quadrupled and the use of the larger sizes of meters would be made necessary, but if accuracy could be insured with a much smaller meter with quicker action, I think it would be better adapted for the purpose. Fuel gas, if it can be manufactured at a price by which it could be sold with profit at a lower or as low price as coal, would prove a larger field than all the kinds of lighting put together, and is certainly worth our while to investigate thoroughly. The owners of the smallest houses of our cities would become our patrons, and a small profit per 1,000′ would represent a wide margin when taking into consideration the large amount that would be consumed.

But is the fuel gas practical, and has there been sufficient progress made to date to warrant gas companies taking hold of it with any assurance of success?

In the first place, what assurance do we require? Do we want some one to come along and guarantee us a profit of 20 per cent. on our investment if we enter the field? If so, the patentees of the different processes might just as well negotiate with the shoemaker as with the gas company. I think all the assurance we want in the premises is, that with certain apparatus we can get certain results from a ton of coal (the kind of coal being specified), or that from a ton of coal we can get a certain amount of available deliverable heat units.

The balance we should be capable of working out ourselves, such as labor, leakage, cost of gas at consumer's meter, and such other data that we certainly should be more familiar with than anyone else.

Of course, the fuel gas will have to have an odor, and must be delivered at a proper pressure, and proper appliances for governing supply and insuring perfect safety will have to be calculated on; in fact, the gas man must try to improve on methods adopted, and do his best to hasten the day when solid fuel in our homes shall be no more—in other words, have got to take hold of the fuel gas business in its infancy, or it will get weaned away from us. Mr. McMillin, with others, has given us some figures on fuel gas which have been verified by practical tests; for instance, he gives us as his opinion that a mixed gas is more adapted for all-round purposes than either coal or water gas alone.

From experiments made, we find that from a ton of bituminous coal making a mixed gas, that we can realize as salable gas 63 or 64 per cent. of the total heat units in the original ton of coal, or about 17,000,000 heat units, besides a residue of heat sufficient to produce the steam for making the above amount.

Of this mixture, 20 per cent. is coal gas made in the ordinary way, which is the only objectionable feature the writer can see in the process. I am inclined to think that Mr. McMillin rather strained a point here in order not to alarm coal-gas men, or else to avoid a too radical change in the apparatus now in vogue for making coal gas.

By his statement, we find that in water gas for labor and repairs cost but seven cents per mile, while coal gas costs for the same items 15 cents per mile. Of course, the proportion of coal gas made by the old method is of more value in heat units than the water gas made by the new method; but what I wished to suggest was this, that if the whole process be made in the cupola, as water gas is now made, whether the results would be the same numbers or nearly so of heat units in amount of gas made with a large reduction in labor, seven cents, making the coal gas cost no more than the water gas for the item of labor repairs. If the mixture can be made in this manner, and I have some assurance that it can be done successfully, then I think it would pay any

company to abandon the use of the present style of gas benches and use the space now occupied by them with more improved apparatus rather than use them at a loss, simply because we have them on hand.

We have pictured an ideal burner for our homes in the forepart of this paper, and I cannot refrain from holding up to your view this fuel, which has no smoke, no dirt, no ashes, and entails to the housewife no extra labor, can be regulated automatically to one steady temperature, and does not require a workingman, after doing a hard day's work, to come home and find a ton of coal dumped on the front sidewalk which has to be wheeled or carried in before night comes on.

Now that we have seen an ideal street light, an ideal house light and an ideal fuel, we will endeavor to show you an ideal gas company, and we cannot do it in a more concise way than to say that an ideal gas company is one that keeps all these ideal commodities for sale at a reasonable price.

This may look visionary on my part to some of you, perhaps all of you, but, nevertheless, I feel that this is the place and time to talk over "our future prospects," and if this paper is the cause of anyone investigating the subjects spoken of or bringing forth discussion regarding the same, I shall feel I have not written in vain.

THE POLICY OF GAS COMPANIES AS TO INCANDESCENT ELECTRIC LIGHTING.[1]

BY F. W. DAY.

Mr. President and Gentlemen:—THE general inquiry for information is evidence enough of the importance of the subject. We hear on all sides the questions:

(1) What effect will the introduction of an incandescent electric plant have on our business?

(2) What amount of capital does it take to put in such a plant?

(3) Can they sell light as cheap as we, and make any money?

(4) Are gas companies any more favorably situated for furnishing electricity than anybody else?

At the meeting held in Dayton a year ago, you listened to two papers, one entitled "Gas and Electricity—Two Interests or One," in which the operation of the gas and electric light business, separately and collectively, was discussed. The second paper had for a subject, "Gas with Electricity," in which the results of a year's experience in running gas and an arc light plant collectively were given, accompanied with many practical suggestions of much value to those who had the introduction of an arc plant under consideration. In fact, the ground was so completely gone over that there is very little room left for saying anything new. However, the enormous sale of incandescent electric apparatus during the last year, together with the rapid improvement in the modes of generating and distributing the current, have added much that is of interest on the subject. We hear wonderful stories of a new system whereby the amount of necessary first investment in distribution plant is divided by 10, and at the same time the loss incident to distribution is reduced from 15 per cent. at a distance of one-half a mile to two and one-half per cent. and no consideration shown to distance whatever. Verily they sound like fairy tales. We might well ask "Where is it to stop?" It would seem that the limits in these directions had well nigh been reached.

It is, I believe, very generally conceded, that for some purposes the arc light is far superior to gas. It has been frequently stated that the introduction of arc lights is accompanied by an increased consumption of gas in the immediate neighborhood where the arc lights are used, which increase is directly traceable to the presence of the arc light. Will this be the case with the introduction of the incandescent lamps? I believe not. The popular idea that there were "millions" in the lighting business has given the incandescent promoters command of almost unlimited capital—and with what result? Two examples will suffice to show. The Edison Electric Manufacturing Co. claim to have at the present time 68 central station plants in operation, supplying current to over 500,000 lamps, and representing an investment of about $12,000,000—much the larger part of which has been thus invested during the last three years—with many large unfulfilled contracts on hand. In this country the first plant running on the alternating system was put in operation in 1885. At or near the beginning of 1887, the Westinghouse people began to place that form of incandescent apparatus on the market, and in less than eight months they had established 14 such plants, supplying current to 15,000 lamps, and representing a capital of about $350,000, with contracts amounting to nearly $125,000 on hand. Later information credits them with having, up to the present time, put into operation 85 plants, supplying current to 175,000 lamps, and representing an investment of about $5,000,000.

In view of these facts is it not safe to predict, that the same energy and push that has characterized the locating of these plants will not rest until every town in Ohio, in the business portion of which 500 lamps could be placed, has been afforded the opportunity of using them; and if they are not furnished by the gas companies therein located, they most surely will be by some one else.

Would a merchant be called enterprising that allowed a new article of merit, and in his line, and which he could have handled with profit, to be sold to a part of his best trade to almost the exclusion of his own goods—simply because he refused to put it on the market, when he could have sold it at a less price and at the same time made as large a per cent. on the capital invested as did the other man?

On the contrary, I think he would be called slow.

The skeptical will no doubt ask, "What has all this to do with us?"

Let us see.

(1) The introduction of an incandescent plant into the business district of a town means the loss of the gas consumption of at least a 5' burner for each incandescent lamp used.

(2) The cost of a plant would depend largely on whether the direct current three-wire or the alternating systems were used, and this, as well as cost of machinery, would depend on the circumstances under which the plant was to be operated, the distance the lamps were from the station, the difference in commercial efficiency of generating apparatus, all coming in for due consideration.

We will suppose that the system requiring the least capital is introduced.

We are told that the amount of investment, including land, buildings, steam plant and complete generating and distribution apparatus, erected and ready for use, would average $25 per lamp; adding 10 per cent. to this as a factor at safety, would make a 1,000-light plant cost $27,500.

The third question requires more in reply. We will take, for example, a plant located in a town, the business portion of which would use 1,000 16-candle lamps, with a 16 c. p. 5' gas selling at $1.50 per 1,000', taking four hours as the average daily usage, the total consumption displaced per month would be 1,000' × 5 × 4 × 30 = 600,000', which, at $1.50 per 1,000', equals $900, or an average of 90 cents per month per burner. Allowing for leakage of a little less than eight per cent., the net profit on the gas sold at that rate to pay 10 per cent. on the capital invested would be 55 cents per 1,000' or $330 per month of 30 days. This would be the net reduction of the profit accruing to the gas business resulting from the introduction of 1,000 incandescent lamps if current was supplied from 6 P. M. to 6 A. M.

Now suppose the lamps were furnished at the cost of a 5' tip, namely, 90 cents per month, the income from the 1,000 would be $900 per month. No meters being used, the charging consumers with the cost of renewals of lamps, the company guaranteeing them to last 800 hours, would have a tendency to limit the hours of use to those specified in the contract, but they would still burn them more than they did the gas jets, allowing 33 per cent. increase for this, and dividing the lamps and hours of use, thus:

600 lamps	from	6 to 10 P. M.,	4 hours	= 2,400 hours.
300 "	"	6 to 12 "	6 "	= 1,800 "
100 "	"	6 to 6 A. M.,	12 "	= 1,200 "
Total of 1,000 "				= 5,400 hours

per day, an average of 5.4 hours per lamp per day.

They would cost with a consumption of six pounds of coal per hour per horse-power, and an average efficiency of eight 16 c. p lamps per horse-power, coal at $2 per ton:

For fuel

125 horse-power 4 hours	= 125 × 4 × 6	= 1,500 pounds.
50 " " 2 "	= 50 × 2 × 6	= 600 "
12½ " " 12 "	= 12½ × 12 × 11	= 1,650 "
Coal used in banking retorting fires,		350 "
		4,100 pounds.

At 10 cents per 100 weight	$4.10
Water at 30 pounds per horse-power per hour = 22,500 pounds = 360' = 2,664 gallons at 50 cents per 1,000 gallons =	1.35
Proportion of superintendent's salary	2.00
Engineer and station man	3.00
Fireman	2.00
Day watchman	1.65
Lineman and helper	2.50
Repairs to engines, boilers and dynamos, at 5 per cent. on investment	1.50
Oil	1.00
Interest, insurance and depreciation at 16 per cent	12.25
Taxes	60
Making total daily expense of	$32.00

For average month $32 × 30½ = $976, increase being but $900, would make a net loss of $76 per month. If placed at 90 cents for those used until 10 o'clock, $1 00 for those used until 12 o'clock, $2.70 for those used until 6 A. M., which would be the cost of a 5' gas burned all night, the total increase would be $1,060 per month, less $976 expenses, would leave a net profit of $84 per 1,000, or $1,008 per annum, a little less than 3¾ per cent. on the capital invested. A plant under these circumstances would hardly be called a bonanza.

In cases where (as Mr. Wood suggested) the waste heats could be used to such an extent as to save 50 per cent. of the fuel, and the balance could be made up of coke breeze, costing one cent per

1. Read at the Fourth Annual Meeting of the Ohio Gas Light Association, Sandusky, O., March 21, 1888.

bushel to handle, the expense of firing would be reduced at least one-half, making the whole cost of production per day :

For fuel, 2,050 pounds, at one cent per bushel	$ .52
Other expenses	27.42
Total	$27.94

In round numbers $28, $28 × 30½ = $854 per one month. With income $1,060 and expenses $854 we have profit $206 × 12 = $2,472 or nearly 10 per cent. per annum on the capital, as estimated by the Westinghouse people.

By the operation of an arc plant in connection with the incandescent, some of the items of expense would be divided, making the net earnings considerably larger.

The cost as estimated here is no doubt larger than it would be placed at by the electrical engineers, but we had better err on the safe side.

The manufacture of a cheap fuel gas, made use of in gas engines, together with the advent of cheap and efficient storage batteries, or accumulators, would lower considerably the amount of first investment and at the same time cut down the cost of production.

However, it will not be long now until our energetic hosts will again be able to give us the benefit of their experience with their new venture, being now engaged in putting in an incandescent plant.

It would seem from the figures here given, that gas companies *are much more favorably* situated for furnishing both arc and incandescent lights, or electric current, than *anybody else*, and that they should pursue the policy of fortifying themselves in their present positions by obtaining authority so to do, if necessary, keep an eye on the public pulse and if they will have it, *give it them*. By so doing they would make a powerful ally of what *might* under some circumstances be a formidable foe. Failure to occupy a field of action in advance of others sometimes results in disaster.

ON THE HEATING EFFECTS OF ELECTRIC CURRENTS.

On March 19, 1884, Mr. W. H. Preece, F.R.S., submitted to the Royal Society a paper on the heating effects of electric currents, showing the strength of current necessary to fuse the fine platinum wire employed for protecting submarine cables from the ill effects of atmospheric electricity. The paper proved that the law that regulates the production of heat is one which can be expressed by the formula $C = a\,d^{3/2}$, "a" being a constant dependent on the metal used, and "d" the diameter of the wire. The current observed was that which heated the wire up to the point of self-luminosity (525° C.).

Since "cut-outs" of the same character as the cable lightning protector have become an essential feature of all electric lighting installations, to act as safety fuses when from accident or design an excess of current is allowed to pass through the conductor, it became most desirable to determine the current that would fuse wires of different diameters, and of different materials, so as to determine the coefficient, a, for all metals. The best material to use and the proper dimensions of the fusible wire to be employed for the protection of the electric light conductors would thus be easily deduced.

Mr. Preece obtained samples of wire of various metals (copper, aluminum, platinum, german silver, platinoid, iron, tin, tin lead alloy, and lead), and of various diameters from 0.004 inch up to 0.040 inch. It is convenient to take these measurements in thousandths of an inch (*mils*), for all our manufacturers and electric light engineers in the United States and the United Kingdom work to this gauge. The conversion of the values thus obtained into the metrical and more scientific system is very simple. The wire to be experimented upon was clamped between two small brass binding screws fixed upon a dry wooden stand.

The author pointed out in his previous paper how the cooling effects of the terminals or binding screws might vitiate the results, and how necessary it was to experiment on wires of sufficient length to prevent any error occurring from this cause. He used lengths of 6 inches to determine the constants for wires free from the cooling effect, but lengths of 1¼ inch with massive terminals to determine the constants for wires used in practice as "cut-outs."

The cooling effect of the terminals very seriously affects the efficiency of the "cut-outs" used in actual practice, and the larger the fusing wire and the terminals the more serious is the error introduced. On the other hand, the greater the lengths of wire used as a fuse the greater the resistance inserted, and the efficiency of the system itself may be reduced. Cut-outs, therefore, should be employed sparingly and with judgment, and the fusing wire should not be so short as to impair the fusing point.

When one considers the irregularities in drawing these fine wires to true cylinders, the difficulty in determining the current at the exact moment of fusion, and the variation in the specific resistance of the metals, Mr. Preece thinks the results must be considered very satisfactory in support of the law.

Three points of observation were taken:

1. The melting point of a small flake of shellac placed on the wire, which may be taken at 77° C.
2. The point of self-luminosity, 525° C. This was only determined roughly in air without the dark chamber he employed previously.
3. The fusing current.

A second series of experiments was made to determine the relative effect of the sudden application of powerful currents on wires of different materials (tin, platinum silver alloy, platinum foil, aluminum foil, silver foil, pure silver wire, zinc foil, copper wire, brass wire, hard drawn bright steel wire, and mercury), such as would occur if in practice a short circuit suddenly took place. An electromotive force of 100 volts was used, and there being no appreciable resistance in the external circuit but the wire, the latter was subjected to the blow of a momentary current of immense and immeasurable strength.

The conclusions derived from these experiments were that the best metal to use for small diameters was platinum, and for large wires tin. Platinum fuses in a wax-like kind of way without explosion or scattering of molten particles. Platinum has great advantages over other materials; it neither tarnishes nor deteriorates. It is easily soldered.

Tin behaves very much in the same way when its dimensions are large. But it is very questionable whether large wires should ever be used for fusible cut-outs. Owing to radiation the surface keeps cool and solid, while the centre is molten and liquid. It bursts with an explosion, and the incandescent particles are forced away radially in all directions with considerable energy.

Fusible cut-outs are effective but somewhat barbarous, and from the absence of any scientific inquiry into their character and judgment in their use, they have in the majority of instances become rather a source of danger than of safety.

A third series of experiments was made to determine the constant "a" when each wire was 6 inches long, and therefore free from any cooling effects of the terminals.

The value of the constant "a" for the different metals is therefore :

	Inches.		Centimeters.
Copper	11684.0	..	2886.0
Aluminum	7948.4	..	1964.0
Platinum	5258.0	..	1299.0
German silver	5203.7	..	1285.0
Platinoid	4860.7	..	1201.0
Iron	3190.9	..	788.0
Tin	1800.6	..	445.0
Alloys (lead and tin), 2 to 1	1455.5	..	359.5
Lead	1512.27	..	373.5

The values in the second column are obtained from those in the first by multiplying the latter by $\frac{1}{(2.54)^{3/2}} = 0.247$.

Since $C = a\,d^{3/2}$ gives the fusing current of any wire of a given diameter, d, inversely—

$$d = \left(\frac{C}{a}\right)^{2/3}$$

will give the diameter of the wire which will fuse with a given current C. Very useful tables can thus be calculated which would be of service to the electric light engineer.

[January 5th, 1888.—In all the experiments the results obtained on wires finer than those recorded, viz., those below 10 mils. were excluded, because it was found that they did not follow the law of the 3/2 power. In the discussion which followed the reading of the paper, Professor Ayrton pointed out that this must be so, and that it followed Mr. Box's researches of 1868 that the current required to maintain a fine wire of a given material at a given definite excess of temperature is approximately directly proportional simply to the thickness of the wire. This has been fully developed in a paper read before the Society of Telegraph Engineers and Electricians, November 24th, 1887 (*Journal*, Vol. 16, p. 539).]

DESIGNING ELECTRIC MOTORS.[1]

BY FREDERICK WALKER.

The electric motor has now become a recognized article of practical utility, and has graduated, as it were, from a mere toy to an important commercial factor. There are, in the market, motors *and* motors, but yet we find in practice that for each and every particular application there exists certain stringent conditions which render it necessary to design a special electric motor that will fulfill the requirements of the particular application, even if a certain modicum of the theoretical 90 per cent. of efficiency has to be sacrificed.

The writer, among many other instances, may quote as an example, the numerous experiments conducted by himself when

1. From the *Mechanical World*.

designing and carrying out the construction of the first two or three electric locomotives of the set that are at present running daily on the tramway between Stratford and Ilford, belonging to the Elieson Electric Locomotive Co. In this case the special requirements were a low speed and a short field magnet, and, of course, the weight had to be reduced as much as possible, the latter condition being a *sine qua non* where electrical traction is concerned. Before dealing with such experiments in detail it will be well to consider the best practical method of arriving at the proportions of the car case, and the proper winding of a motor to suit the exigencies of electrical traction.

Taking an ordinary tramway car, weighing 1¾ tons, carrying 40 passengers, the united weight of whom is 2 tons, and allowing 1½ tons for 60 accumulators with an electric motor and accessories, the total weight that has to be propelled along the tramway track, at the regulation rate of speed of 7 miles per hour, is 5¼ tons. Upon an ordinary level track, under favorable conditions, the mean tractive force required should be about 26 lbs. per ton; therefore, since the maximum speed is

$$\frac{7 \times 5{,}280}{60} = 616 \text{ ft. per minute,}$$

and the load is

$$5.25 \times 26 = 136.5 \text{ lbs.,}$$

and the actual horse-power absorbed during the run at this rate of speed is

$$\frac{136.5 \times 616}{33{,}000} = 2.5 \text{ h. p.,}$$

and, adding the loss due to friction of the speed, reducing gearing, &c., at a rate of 15 per cent., the total becomes 2.87 h.p.

When ascending a gradient of, say 1 in 80, the power absorbed is proportionately greater, for the tractive force becomes

$$\frac{2{,}240}{80} = 28 + 26 = 54 \text{ lbs. per ton,}$$

and the total power required to maintain the former speed of the car up the incline is

$$\frac{5.25 \times 54 \times 616}{33{,}000} = 5.2 \text{ h.p.,}$$

and, since 1 in 80 is a comparatively light gradient, it serves to illustrate the range of actual mechanical force that is required in order to drive an ordinary tramcar along a variable track. In designing the motor and gearing, there must not be a single pound weight of surplus material, as every pound of dead weight requires nearly 8 foot-pounds of energy in order to propel it at a speed rate of 7 miles per hour on a level road. Now, in order to overcome the *vis inertia* of the loaded car, that is, start it from a position of rest, requires an approximate tractive force of 78 lbs. per ton, or a total of 7.7 h.p., representing the necessary initial force required. Suppose that there exists upon the track no gradient steeper than 1 in 80, and the weight of the loaded car and its accessories is 5¼ tons, and that we have to provide a motor or motors wherewith to drive it at a speed of 7 miles per hour, the maximum power required is, as we have seen, 7.7 h.p., but to which we must add the power absorbed by the motor, and also by the gearing. If the latter be properly adapted it should absorb but 15 per cent., and the motor should at least possess 70 per cent. of efficiency when running at its critical speed. Now the maximum electrical horse-power that has to be exerted for about one minute, while overcoming the *inertia* of the car, is approximately 8,300 watts, and the discharging E. M. F. of the accumulators is about 1.98 volts, the available E. M. F. from the 60 cells is 118.8 volts, and the maximum current is 69 amperes. Upon this data, therefore, we may begin to calculate the dimensions of the motor, remembering, however, that although 70 per cent. is a low efficiency for an electric motor, and that it is possible to construct one to absorb about 9.5 per cent. of the electrical energy, it is only in very exceptional cases where the latter would be applied for the requirements of electrical traction. An ordinary tramcar wheel is 30 inches diameter, or 15 inches from the rail to the centre line of the axle. The floor of the car must not be raised above the centre line more than 16 inches, and allowing 4 inches for clearance at the bottom and top, the motor cannot exceed 22 inches in diameter over the pole-pieces. In practice, however, we should find that an armature 15 inches in diameter would perform the necessary work, and, assuming that we use bent wrought iron field magnets of the shape usually known as Siemens's, the iron core would be 1⅝ inch in thickness, and each magnet core 14 inches in length, and the width 10 inches, of course corresponding to the armature, which will be 10 inches in length over all when wound. Now we know that the initial and maximum running current, C^1, is 69 amperes, and that the initial E. M. F., E, at the terminals is 118.8 volts; therefore the resistance, r, of the motor will be deduced from $C^1 \times 1.35 = 93.15$, being the current, C, that will pass through the motor when it is absolutely stationary. The resistance, r, will be, therefore,

$$\frac{118.8}{93.15} = 1.2 \text{ ohms.}$$

Now, any coil or coils of wire revolving in a magnetic field must have a potential generated in it or them; therefore, as the motor in question is to run at a reasonable speed to suit the intermediate gearing, say 650 revolutions per minute, a counter-electromotive force, e, is set up in the wire tending to check the flow of current from the accumulators, because it is acting in an opposite direction. The counter-electromotive force, e, in this case will have a value of about 85 volts, and, therefore, from the above data we may estimate the theoretical efficiency of the motor.

The current absorbed when the critical speed is attained is

$$\frac{E - e}{r} = C,$$

and this represents the maximum efficiency when the motor is performing most work and absorbing least electrical energy. Substituting the known values in this equation we get

$$\frac{118.8 - 85}{1.2} = 28 \text{ amperes,}$$

so the values of the varying current in amperes are as follows:—

$C = 93.15$ amperes standing still.
$C^1 = 69.00$ " moving slowly.
$c = 28.00$ " critical speed.

Now the proportion of energy utilized as tractive force and the energy actually absorbed by the motor is represented by the fraction

$\frac{e}{E}$; or substituting the values,

$\frac{85}{118.8}$, or 71 per cent. efficiency.

I am of opinion that the counter-electromotive force, e, of a motor is analogous to the expansion of steam in a steam engine cylinder, with regard to its economical results, for we see at once that the most effective and economical electric motor would be one in which the values of the E and e were nearly equal. This would mean a high rate of speed per yard of armature conductor, and since in the present case such a speed is not admissible, the result could only be obtained by largely increasing the diameter of the armature. This is likewise impossible, because of the limited space occupied by the motor and gearing, and under any circumstances a motor possessing a high degree of efficiency is too heavy and cumbersome for application to tramway traction. Taking into consideration the enormous additional weight of a motor of 90 per cent. efficiency, and the power absorbed in transporting such a weight, it has been found more practicable to employ a lighter motor with a less commercial efficiency. There have been of late years several patents taken out, based upon Froment's bar armature, solely with a view to obviate what the inventors chose to consider a serious disadvantage, viz., counter-electromotive force. The efficiency of such a motor must, of course, depend upon the single statical pull of the field magnets upon each bar in succession; therefore the current absorbed must be enormous in proportion to the mechanical work done upon the spindle.

I have found in practice that the best armature core is one built up of a number of segments, forming a perfectly circular ring, each layer of which is carefully insulated by the interposition of sheets of paper soaked in shellac varnish, and the whole taped over ready for winding as a Gramme ring. The wire must be chosen of sufficient sectional area to carry the maximum current for a short time without becoming unduly heated, and the length of the armature conductor must also be proportionate to the counter-electromotive force, e, that is required, and the resistance between the brushes; or, to put the matter plainly, the resistance between two opposite segments of the commutator, is best when about 0.55 of the total resistance, r, which has been established by calculation. The commutator should be divided at least into 60 parts, and should possess a good bearing surface for the brushes, in this case at least 5 inches clear, for it must be borne in mind that the tangential contact of the brushes is exceedingly fine when the commutator is perfectly circular, and also that an electric motor, unlike a dynamo generator, receives the current upon the commutator suddenly, the greatest current, of course, passing when the motor is at rest, and is required to move. The end bearings should be long, so that the intervening film of oil shall not be driven out by centrifugal force when the motor is running, and also in order to distribute the pressure of the rotating spindle over as large a surface as possible. Every opportunity should be afforded for the free ingress

of air around the revolving armature, so that the temperature may be reduced as much as possible.

There are many methods that have been employed with more or less successful results of varying the speed of an electric motor when applied for the purpose of traction. Resistance coils are frequently arranged so that they may be interposed in the circuit by means of a multiple switch at will. This method is exceedingly wasteful, as the reduction of speed in the motor is accomplished by the absorption of a proportionate amount of the electrical energy in heating the resistance coils. Another method is to cut a number of accumulator cells out of the circuit, and so reduce the E. M. F. This is not practicable, because the accumulators are then unequally discharged, and there is a corresponding waste of energy during the process of recharging. I have found in practice that it is better to arrange a compound switch so that, in the case of a single motor, the field magnet connecsions could be varied at will. Where two or more motors are employed it is an easy matter to arrange a circuit, governed by a proper switch, so that the motors may be run singly, in series, multiple, or multiple series. An essential point in a motor for purposes of tramway traction, or for electric launches, is a simple method of reversing the motion. This may be done by means of a duplicate set of brushes, or by reversing the direction of the current around the field magnets; or special differential gearing may be interposed between the motor spindle and the work.

Without doubt the time is approaching when electrically propelled tramcars and boats will be no longer isolated cases, but will be among the common sights of every-day life upon every river and in every large town in the kingdom, and engineers will be as familiar with the electric motor, in theory and practice, as they are at present with the steam engine.

ALTERNATING *vs.* CONTINUOUS CURRENTS.[1]

BY M. M. M. SLATTERY.

A FEW days ago, when I had the honor of receiving an invitation to read a paper before this club to-night, relating to the alternating system in parallel arc, to be in reply to Mr. Leonard's paper, I felt, understanding Mr. Leonard's proclivities, that the usual stereotyped attack would be made upon a system which has alike elicited the admiration of those who have disinterestedly given the subject some thought, and the most rancorous feeling on the part of those whose business has been placed somewhat in the background by the rapid developments which have taken place in this comparatively new field of electric lighting. In a moment of unguarded enthusiasm I accepted the invitation. As some of you may know, I am practically engaged in the alternating branch of electric lighting, and my time is so much occupied therein as to almost entirely preclude me from having time to either write or read papers. I regret, therefore, that in this short paper I shall not be as comprehensive as I should wish, and will principally confine myself to replying to some of the salient points in Mr. Leonard's paper.

We are told that the following are the sum total of the vital factors in a general supply system of electric energy, viz.:

1st. Cost.
2d. Economy (efficiency and depreciation).
3d. Reliability.
4th. Safety to life.
5th. Variety and value of the possible sources of revenue.
6th. Effects upon existing property.

The factor of distance over which you have to transmit the electric energy is conspicuous by its absence, not being considered of sufficient importance to be enumerated in the list; we shall see presently of what value this factor is. Of course Mr. Leonard, as is customary with advocates of the low tension system, starts out with an explanation of the transcendent merits possessed by the three-wire system, and expresses in the usual terms the 66 per cent. saving over the two-wire system.

In the paper read by Mr. Leonard, elaborate tables of figures are given, into which I will not attempt to follow him in detail to-night. It would only weary you, and, as you are aware, if the premises are once granted, almost anything can be proved by figures. All I would say is, examine those figures yourselves, but do not assume that the data are correct.

It is a very ingenious rhetorical device to take the cost of the Edison system for distribution over a small area, and compare it with the cost of the induction system over a small area, and thus show that, taking price of converters into consideration, the Edison is the cheaper. This is avoiding the question. The chief claim made for the alternating system is that it can reach customers and supply a market that the low tension system never can.

Another point to which I would call your attention is this: Mr. Leonard assumes the cost of copper to be 16 cents per pound; he had to bring his estimates at all within bounds. Now, we all know that the price of copper is more like 25 cents than 16 cents. The variation in the price of copper affects the low tension system much more seriously than it does us—another point in favor of the induction system. It may be said, "Yes, but you have to use copper wire in your converters as well as your lines." True, but only to a limited extent, the cost of the converter being largely made up of the iron and the labor. The quantity of wire in a good converter is but small.

Another reason why I do not care to take up your time with a detailed discussion of these figures and tables is that the field has been pretty well covered by Mr. Stanley in a paper recently read by him in Boston, and also for the reason that Professor George Forbes, who is recognized as one of our best authorities, has said with regard to the theoretical economy of the three-wire system that "this may suit American financiers, but is not electrical engineering."

Mr. Leonard is not warranted in assuming a thing in order to enhance the value of his claims; he says we may look forward to improvements in the 100-volt incandescent lamp which will result in 30 per cent. reduction in the cost of conductors in the three-wire system. I have been engaged in the manufacture of incandescent lamps for some 12 years, and, as I have to follow the subject up closely, I trust I ought to know a little about the improvements which have been made in the past, and the possibilities ahead for the future, and I find that for the four years just past very little has been done towards improving, either the life, or the efficiency of incandescent lamps.

A so-called improvement by a well-known company, the Edison, has lately been trumpeted in every direction. Why, Swan has been making such a lamp in England for some five years, and so could this same company have made them if they only employed methods which are equally within the reach of all. The reason for this recent claim is obvious; it is an off-set to the large number of lamps per horse-power claimed for the induction system. With regard to the claim put forward on behalf of the Edison company of being able to obtain twelve 16 candle power lamps to the horse-power, I will not dispute it, but simply say that the gentleman who was for four years the mechanical engineer of the Edison Electric Light Company has, within the past six months, given sworn testimony in these words: "In the direct current central station system, the maximum which, to my knowledge, has so far been obtained, is between six and seven lamps to the horse-power."

Now, gentlemen, a 100-volt lamp, such as the Edison, could certainly be made which would run, say 12 to the horse-power, yes 15, or 20, but what would be the life of those lamps? In all probability, as far as our present knowledge goes, very brief. I prefer, in a case like this, to rely upon an absolute statement of fact rather than upon any promises or guarantees or possibilities.

The limit of voltage at which a lamp can be made so as to have a reasonable life has, it seems, been reached in its upward direction at about 110 volts. It was anticipated a few years ago that a high volt, small current lamp was the great desideratum. Scarcely any progress in that direction has, however, been made for some time, as I have just said, and the tendency, in fact, now appears to be the other way, *i. e.*, toward low resistance lamps—say 50 volts to 70.

The continuous current system is far more susceptible to heavier fluctuations than the alternating, owing to the total absence of automatic regulation in the former; and, when it is remembered that the light intensity of an incandescent lamp does not vary as the potential difference at its poles, but in a much greater ratio, it will be readily understood that the fluctuating system has a much more hurtful effect upon the delicate incandescent lamp than the non-fluctuating system. I am supported in this statement by not the opinion, but by facts deposed to by the gentleman referred to. He says: "The usual percentage of loss in the carrying wires of a direct current system is 15 per cent., and even with this heavy loss the carrying wires attain a stupendous weight. The practical result from the introduction of this loss in the main wires of the direct current system is, that when such a plant is running fully loaded, the E. M. F. at the dynamos, will be 15 per cent. higher than at the lamps; whereas, when only lightly loaded, difference in E. M. F. at the dynamos and lamps runs down to a much smaller figure; therefore, in order to maintain the lamps at a uniform brilliancy, the E. M. F. at the dynamos must be carefully watched and adjusted to suit the varying requirements of the load, as in the absence of such care the brilliancy of the lamps will fluctuate and give rise to serious lamp breakage. This regulation of the E. M. F. is accomplished partly by regulating the field magnets of the machine and by the introduction of artificial resistance in the main carrying conductors. The attention to secure these results is expensive, and the devices for accomplishing them very costly.

There is another matter in connection with central station arrangements which, it seems to me, disposes of the question of the relative commercial merits of the two systems in a conclusive manner, and that is this: The advocates of the low tension systems admit that as far as actual wire goes, the 1000-volt distribution is more economical than is the 100 or 200-volt—that is a pal-

1. Read before the Chicago Electric Club, March 19, 1888. The second of a series of papers upon the subject, "The Continuous Current *vs.* The Alternating Current," before the club.

pable matter. But, say they, in addition to the danger and other objectionable features of your plan, the cost of your converters is so great as to neutralize whatever advantages you may have in this way. Without going into that point for the moment, it will be seen that the converter itself costs no more whether the current supplying it comes from 1000 or 10,000 feet away; that being so, the difficulty which stares the Edison system in the face is the practical necessity of picking out for their central station about the most expensive piece of real estate in the district to be lighted. They must be near the centre. They say so themselves. On the other hand, with the high tension system, you may have your central station in the outskirts of the town on cheap land, perhaps on a canal bank or railway siding, so as to unload your coal direct into your boiler room, which may itself save many hundred dollars per annum, while the extra length of the comparatively small conductors would be but a bagatelle compared with the real estate investment in the centre of the town. That I am not speaking off the book in this matter will be seen when I quote a passage from a document issued by the Edison company, entitled "Information to Agents," and relating to the desirability of centrally locating the station. It is as follows:

"NOTE: In a given district to be lighted, the best conditions of economy in street installation are fulfilled when the station is located in the centre of the district. If the station is moved one-quarter of a mile away from such centre the cost will be about doubled. If the station is moved one-half mile away from centre, the cost will be about quadrupled. * * * there need be no hesitation in locating it in the most central locality. A few hundred dollars' increase in cost of lot will often save thousands in cost of street installation."

Now, as to the lamp, the reasons for the prominence which a 50-volt lamp is at present acquiring are four-fold, namely, cheapness in manufacture, efficiency, reliability, and that while it is the lowest limit in volts that we should allow ourselves (for distributing reasons) it exactly suits the most efficient construction of converter.

The fewer the number of turns of wire in a converter the better, with proper limits; and, as in a 50-volt converter we have only half the number of turns that we should have in a 100-volt, the advantages of a 50-volt lamp for our purpose will be apparent; the fact also is that, while the manufacture of the 100 and 110-volt lamp has received the greatest attention by manufacturers for obvious distributing reasons, the 50-volt lamp has received comparatively little notice, not being recognized as a factor in a general system of distribution.

The Fort Wayne Jenney Company is now making a 40 watt 16 candle power 50-volt lamp. This lamp could just as well have been made long before this, but there was no such demand for it as now exists. If such improvements as Mr. Leonard predicts for the 100-volt lamps are likely to take place and the ratio of the present efficiency of the 100 and the 50-volt lamp holds good, we might look forward to a corresponding increase of efficiency which would enable us to reduce the cost of our converters in nearly the same proportion; that is to say, the cost of a 40 lamp converter would be very little more than for the present 25 light. There would also be the proportional saving in the cost of interior wiring.

Much has been said and written by the opponents of the induction system about the respective first cost of an induction installation and a low tension continuous current installation, viz.: that the low tension is cheaper for very short distances. This sounds very much like a man who had a continually growing business and required an engine, saying that a small engine was cheaper for him than a larger one, because the smaller engine just then met his requirements; after a little time he finds it necessary to dispose of his small engine at a considerable discount for a larger one that will be more adequate to his growing needs. Why not put in at the first that system which will meet any and every illuminating requirement for all time, both at points near to and remote from the source of generation.

I do not know whence the information has been derived, but the theory does exist that with the reduction of the load in the multiple arc induction system there is not a proportional reduction of the energy supplied to the circuit, and that consequently the loss of energy in the line does not decrease proportionately with the load. While this theory would and does apply to a series system of transformers it does not apply to the multiple arc induction system, the latter standing in the same relation with regard to the energy supplied to each circuit as the low tension multiple arc. Upon another occasion I trust to have an opportunity for bringing forward mathematical deductions and power curves incontestibly proving this fact.

No doubt a system cannot be considered a reliable one unless you are able to multiple arc your dynamos; well, we are able to do this. It used to be regarded as difficult; but, with a great many of these apparent difficulties, we need only to understand their nature in order to overcome them, and although at the present moment we cannot couple as many together as we should wish, I venture to say that by the time such necessity arises we should be ready to meet it. It is stated that we cannot multiple arc dynamos economically, as occasionally one dynamo will shift the load and the other dynamo not only will take it, but will try to drive the other as a motor. In an incomplete system this is just what takes place, but in a complete system when any such irregularity occurs, a device is brought into operation that regulates the speed of the engine when any variation therein is inclined to take place, thus maintaining the speed of all the dynamos coupled in multiple, and their potentials uniform, and, consequently, an economically working system.

A good deal has been said from time to time as to the dangers of the induction system, and notwithstanding the repeated exclamations and statements of those who are acquainted with alternating currents and their use, yet only a week or two ago Mr. Leonard in his paper read before this club attempted to resuscitate this scare, which we supposed had been forgotten. Professor Elihu Thomson has publicly stated that he has taken a 1800-volt alternating current without serious inconvenience. I have myself, as have several of my friends, taken 1000 volts, and in all the cases with which I am acquainted nothing more than some temporary discomfort followed. The most serious case of which I ever heard was that mentioned by Mr. Carpenter Smith, at the Boston convention. In that case the man was not permanently injured, although under the influence of the current for quite a considerable time. Although I would not go so far as to recommend the use of the 1000-volt current as a morning beverage, yet it is absurd to let the impression go abroad that it is necessarily or even probably fatal. We recognize the fact that an electric current of 200 volts is less dangerous than one of 1000 volts; of course, we know that. Does it, however, follow that we shall throw to the winds every advantage that this higher pressure gives us? Because a buggy is less dangerous than a locomotive, do we therefore abandon the railroads? Because an arc light system requires more pressure than the low tension are we therefore to abolish every arc light in the country? These questions answer themselves. So in time will the other, and "those who came to scoff remained to pray."

As evidence of how safely we can work with the induction system, we find that there is nothing to prevent us placing our lamps upon existing gas fixtures, unless it be ignorance, or not employing the proper precautions to render the work absolutely safe. It is suggested by some that in order to prevent the high tension primary current being dangerous to life, in the event of a leak between the primary and secondary coils taking place, to ground the secondary; that if a leak took place from the high tension circuit to the low tension circuit, and there happened to be a ground somewhere else on the primary circuit, no harm whatever could occur to a person taking hold of the terminal of an incandescent lamp, and at the same time touching a gas fixture. While this arrangement makes the use of the lamps by the customers absolutely safe, it subjects the entire system to a strain on the insulation, which I don't think is quite wise, and, instead of grounding the secondary, I think the better plan would be to ground a sheathing of metal, interposed between and carefully insulated from the primary and secondary. So far as safety to life is concerned, this is just as good, but has the recommendation of not subjecting the insulation throughout the system to any strain whatever, and has been used for some time with satisfactory results in the converters made by the Fort Wayne Jenney Electric Light Company.

A charge laid at the door of the induction system is that of unreliableness, and a few small break downs which have occurred are exaggerated to a considerable extent by those interested in other systems. Such matters are liable to occur in all new installations, the Edison not excepted. They are simply indiscretions, errors of youth, and not faults of the system as such. In a very short time the experience we have gained in this respect will bear due fruit, and it will be found that the induction system will be just as reliable as the continuous system. In the absence of gross carelessness there is no reason to the contrary, and, indeed, down to the present time accidents have been rare.

With regard to an alternating current dynamo of 1,000 volts being more liable to burn out than a low tension continuous current dynamo of 110 volts, and that the depreciation of the latter is less than the former, this seems to me to be nonsense. Understanding the nature of the work that a dynamo has to do, and with proper experience in construction, there should exist no reasonable doubt about making one dynamo to work as reliably as the other. This is purely a mechanical matter and the ingenuity of our mechanics is equal to any such emergency as that, and, as to depreciation, I venture to say, in fact, I know, that the armature of an alternate current dynamo of the kind I have had any experience with at full load, does not arrive at anything like the temperature a low tension Edison dynamo does under the same conditions, and we all know what high temperature in a wire has to do with the deterioration of its insulation. Furthermore, by reason of the small quantity of wire necessary in the armature of the alternate current dynamo, we can afford to occupy more space and thereby have less crowding of the wire; thus we have an opportunity of increasing our insulation in proportion to the E. M. F. required, and yet keep within the limits of great compactness. For instance, in an 800-light machine made by the

Fort Wayne Jenney Electric Light Company, there are only 20 pounds of wire on the armature.

There has been some little uncertainty about the action of converters in respect to the fuses inclosed in the converter box frequently and mysteriously melting. This, however, I find is attributable to the temperature of the converter at full load not being calculated as a factor with the current for the melting point of the fuse, and I think it will be much better for us to be satisfied with an external double pole fuse at the point of junction of the primary coil with the primary line, and a double pole fuse on the secondary circuit as close to the converter as possible; this arrangement thoroughly protects the system, and a possibility of the failure of the converter becomes a very remote one.

It is said that the operating of motors by alternating currents is not a success. Well, it may be admitted that at the present time the commercial operation of alternate current motors has not attained very large proportions, but who is presumptuous enough to say that, when the present systems of alternate current supply are as old as the continuous, there shall not be as many and as satisfactory motors running on alternate currents as on continuous? Is it for any gentleman connected with the Edison company to stem the tide of invention, to say that the acme of perfection is reached in the triune system of that august body, and to thunder forth electrical excommunication on all heretical expounders of the faith? I trow not. Alternate current motors have been made which have in them the elements of success, and the subject is daily attracting more and more attention from some of our most talented workers in that direction, both practical and theoretical, as examples of which I may mention the valuable papers read quite recently, by Dr. Louis Duncan, before the American Institute of Electrical Engineers, and the earlier one read some months ago by Professor Elihu Thomson, with which no doubt most of you are familiar. The mere fact that motors will work with an alternate current is, of course, well known. The difficulties have been in the regulation. But a difficulty, gentlemen, is merely a thing to be overcome. That is what the difficulties are for. These will be overcome, as have so many others in the grand field of electrical progress. Why, I remember hearing Dr. Werner Siemens say with his own lips that it was hopeless to expect to make a dynamo with a higher efficiency than 50 per cent. He lived to see himself mistaken, and perhaps others may do the same. "Not ten years ago the divisibility of the electric light," as it was called, was ridiculed as the chimera of an enthusiast's overheated imagination, and, nevertheless, where are we to-day?

The objection to the induction system on this motor question is based on the assumption that it is a desirable thing to operate motors on the same circuit as lights. Now, although at first sight this would seem to be the case, and although I am not prepared with any formal objections to that course, yet I do know of one company that has been running motors on the same circuit as lights, but is now running a separate motor circuit instead, in addition to its lighting circuit. So that there is such a difference of opinion on the question that it cannot be fairly disposed of by any *ex-cathedra* utterances of the advocates of any particular system.

One curious fact, which I think is not very generally known, though the information is public property, would seem to show that the Edison company does not regard the alternating systems as such insignificant opponents as it would have us believe. The advocates of the Edison system profess to regard all these induction high tension systems as inferior to their own, and as almost beneath contempt, yet, singularly enough, I find that twelve months or more ago the Edison Electric Light Company, of New York, thought enough of one of these systems—a European one, the Zipernowski—to acquire the exclusive rights in North America to use all the patents on that system, and to obtain certain privileges with regard to those patents. To say the least, it is strange that a company should be willing to negotiate for so worthless a system as they pretend it is. Does it not rather show that they are more frightened than they say, and are providing for themselves a *locus penitentiæ?* I think it does.

It may be considered that my remarks sound like a direct attack upon the Edison company's system, but I have frankly admitted wherein the induction system is weak, and only claim such advantages for the latter as are warranted by fact, and when we know of cases where, after large installations have been put in and paid for, such, for example, as that of Tyrone, Pa., the investors found upon careful consideration of the question, that they could make more money by setting aside their original investment and changing over from low tension continuous (three wires at that) to high tension induction, that I have not spoken too strongly. But, gentlemen, whatever I or anybody else may say in favor of one system and in condemnation of the other system, will, from a commercial point of view, affect the subject in dispute very little, and we may rest assured of one thing, that the public at large, whose business it is to study these questions, have discrimination enough and practical knowledge sufficient to enable them to make a wise selection. The respective systems, low tension continuous and high tension induction, are now before the public, and the ascertaining of their respective values is within the reach of those who desire to know them; they will perceive that claiming that a thing cannot be done does not settle the question, for they will see it being done, and the great question of the public will be what does this cost? What profit can I make upon my investment? Be confident that the public will not go far wrong when the information it seeks is placed within its easy reach.

COMPARATIVE VALUE OF THE CONVERTER AND CONTINUOUS CURRENT SYSTEMS OF ELECTRICAL DISTRIBUTION.[1]

BY E. P. WARNER.

UPON signifying my willingness to take part in the present discussion, it was with the distinct understanding that it should be a comparison of direct systems of distribution with converter systems, and embrace any and all systems, applicable to central station work. When the card announcing the programme so far as complete appeared, I was surprised to find the matter to be discussed very indefinitely stated. It seemed, however, to be settled by general consent of the members of the club that the discussion should take the form of a comparison as to value of the low tension continuous current systems with the high tension converter systems of electrical distribution. This reminds me of the numerous discussions of late, regarding the relative value of the high speed, high pressure steam engines, as compared with one of slow speed and low pressure; and viewing the matter as I do from a strictly non-partisan standpoint, it seems to me that the conclusion arrived at will be about the same, that is that each of the systems, as each of the engines, has its particular advantages under certain conditions.

Having followed somewhat closely the progress made in the development of the systems under consideration, I have come to consider the low tension continuous current systems as well suited in every way for distribution over a certain area from a central point, its extent being limited principally by the cost of conductors, and the loss of electrical energy in overcoming their resistance, while the high tension converter systems have appeared to possess certain characteristics that particularly fitted them for long-distance distribution, and that seemed their legitimate field of use. I do not propose to-night to employ either mathematical or geometrical demonstration, but to briefly go over the points in the two kinds of systems that seem to me to furnish a basis for comparison.

In H. Ward Leonard's paper, read before the Chicago Electric club on March 5th, a brief enumeration of the vital points in a supply system is given, which without doubt covers the ground pretty effectually, despite the charge made that he has neglected the matter of distance.

The main features of a low tension system such as the three-wire, are so well understood, and the means for accurate determination of cost, efficiency, etc., are so simple that I will not take up your time in going over them, but say that the statements made by Mr. Leonard regarding the three-wire Edison system are in the main correct so far as my experience goes.

Now for the converter systems. The question might be asked here "Why do we convert?" In answering the question the advocates of such systems are, as a rule, not at a loss for reasons, and put forward claims for the converter of so startling a nature that I can not help the thought that their wishes lead their judgment.

A recently published table of determinations of efficiency of converters under various loads, the result of calorimeter tests by Professor Ayrton, shows a very low efficiency under light load—a result to my mind very naturally to be expected. We know that in the nearest approach to the ideal dynamo that we are able to produce, the showing in efficiency under light load is not all that could be wished, and I think that to a certain extent the working conditions of a converter and dynamo are similar, and many of the troubles encountered in dynamos are met with in the converter; therefore, when we take into consideration the number of converters usually employed in an installation of only moderate size the matter becomes one of great importance.

Before proceeding to a consideration of these troubles, it would perhaps be well to mention briefly some of the objects sought in the construction of converters. They are, reduction of length of wire, and number of turns, also the weight and cost of all material used with a high general efficiency under all conditions of service.

The showing has been made that it is not economical to work converters with a high induction, and this fact stands as a bar to progress in the direction of reduction of material. Careful lamination and ventilation of pure, well annealed iron do not to any marked extent improve its storage capacity, and until we find an iron differing greatly in molecular structure from any at present in use we shall probably be without a remedy.

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1. Read before the Chicago Electric Club, April 2, 1888. The third of a series of papers upon the subject "The Continuous Current *vs.* The Alternating Current," before the club.

I do not think the statement fair as made by William Stanley, Jr., at the conclusion of a paper read before the American Institute of Electrical Engineers, that to alternating or similar currents iron offers true storage capacity for all values of magnetization below the saturation point. It seems to me calculated to lead the student astray regarding the economical use of iron for this purpose. He would very naturally take it that so long as he did not pass the saturation point he would be getting a fair return, when as a matter of fact, he must stop far short of saturation, or suffer serious losses from a variety of causes. A large quantity of iron in proportion to wire is therefore a necessity in a converter designed for high efficiency, as the magnetization should at no time reach too high a point.

Another reason for working at a low induction is hysteresis, or molecular friction of the iron core. It has probably occurred to many of the members present that the heating of iron while undergoing rapid reversals of magnetizations could not in all instances be attributable to Foucault currents; also that the heat increased more rapidly than the intensity of magnetization; and again that the heat increased with a decrease in time between complete reversals.

Now, in the case of a converter any heating of the iron means a loss of electrical energy, and it is only by carefully restricting the degree of magnetism of the core, fine lamination, and good ventilation, that excessive heating can be prevented. It seems to be impossible to entirely prevent this loss.

The requirements for self-regulation of a converter are in practice such as to call for a sacrifice in efficiency in order to secure regulation. This loss is said to be small in certain forms of converters, but it goes nevertheless to make up the sum total.

To quote from an article on "Electrical Distribution by means of Transformers," by J. K. D. MacKenzie, published in the *Western Electrician* of March 10th: "The question of mutual induction in superimposed layers of wire one with another is of importance, and it is easy to see that since each wire through which an alternating current is flowing serves to induce a current in an opposite direction in the one next to it, which acts against it and against the third or succeeding one, and so on throughout the series, a loss is bound to result."

In considering this point it has occurred to me that this loss must be greater where very high electromotive force is employed in the primary, owing to the greater number of turns of wire employed in construction. I will make use of the words of M. M. M. Slattery, in a discussion which followed a paper read by him at our last meeting: "You are familiar with the alternating current type and you are aware that the greater the number of convolutions of wire, the greater the reactive effect. The same law holds good to a very much higher degree in the operation of the converter, and that is why we keep the number of convolutions of wire in the converter as low as possible, that the ideal converter, as the ideal dynamo, would therefore have but a single turn of wire." We see that in this, the electricians who seek to annihilate distance by the use of small conductors and high E. M. F. meet with a serious obstruction.

In the matter of distribution it strikes me that the size and location of converters must greatly affect the results. In the case of an installation of say 500 lights, it has been the practice for some time past to connect the secondaries of several converters in multiple arc to one pair of feeders that supplied the lamps. A rather unexpected trouble has resulted from this method of connecting. Should one of the converters of a group give out at a time when the number of lamps in service exceeds the capacity of the remaining converters, the fuses of these converters will blow out in rapid succession, and all the lights be extinguished. The remedy for this is said to be running separate local circuits for each converter, and at first sight this looks to be unobjectionable, but when we come to the cost of an installation for wire and labor, we can not fail to see that in nearly all cases the expense of running separate local circuits, would considerably exceed that of a single circuit. We can not buy several small insulated wires equaling in conductivity a larger wire at the same price.

Now, as to the dangers to life and property from the alternating converter system, it can not be held that the dangers are no greater than with the low tension system, whether alternating or continuous. Admitting that the safeguard to consumers provided by grounding one side of the secondary or local circuit is perfect, there is still considerable danger from the exposed overhead wire. When we take into consideration the great number of telephone, telegraph and other wires threading the streets of many of our cities, and the frequency with which crosses occur between the wires of the different systems, it becomes a pertinent question whether it will be found possible in practice to provide against accidents of such nature and frequency as to seriously detract from the value of a system. For this reason it may be found inadvisable to raise the E. M. F. above 1,000 volts, or even so high. While it is undoubtedly a fact that a number of persons have taken the shock from an alternating current of 1,000 volts and lived to tell of it, there are many people to whom it would be extremely hurtful, if not fatal. The danger of fire in buildings where the primary wires of a 1,000-volt alternating system are permitted to be placed, is beyond question much greater than with a continuous current system of 200 volts. Again, a cross between a telephone wire and the primary of the alternating system would be almost sure to burn the instrument at the subscriber's station, and might set fire to the building. One thing that increases the danger from this source is the fact—admitted by users—that it is practically impossible to so perfectly insulate the wire that no escape shall take place.

It has been claimed by several writers that if the primary wires of an alternating system endanger a building, so do the wires of an arc light circuit, where the E. M. F. may be as high as 3,000 volts. This is true to an extent, and we all know the precautions that have been deemed necessary by insurance people. But let us look at this matter a moment. In an arc lighting system it is not often that we find 25 lamps in a single building, which number would be required to bring the E. M. F. up to 1,000 volts, and this would only be found from the point where the two wires entered the building up to the first lamp on either side, gradually decreasing as the centre lamp is approached. The number of arc lamps in use in a building would therefore determine the danger. I think that in actual commercial lighting the average number of lamps to a building will be found far below 25; whereas with the alternating 1,000-volt system every building entered by the primary wires will be subjected to an even greater danger than it would be from an arc circuit furnishing 25 lamps.

Now to compare the high tension alternating systems with the low tension systems in the matter of insulation. Commencing at the dynamos we find that a much higher insulation is necessary on high than on low tension machines, and leaving out of the question the increased cost for insulating material, it is apparent that much greater care must be taken of the high tension armature in the matter of cleanliness, than of the low tension; also that a comparatively slight deterioration of the insulation of the high tension armature will entail serious loss of energy; and where an E. M. F. of 3,000 volts is maintained, this deterioration and loss may amount to a very considerable percentage of the total energy without resulting in the destruction of the armature. To this the advocates of high tension will answer—we will instruct our dynamo tenders to keep things clean, and the insulation will not deteriorate. Many of you no doubt know from experience how instructions instruct, and how frequently the insulation, which is advertised not to, proceeds to deteriorate.

The insulation of the primary wires of a high tension system from each other is a matter of far more importance than that of the armature wire, and in the case of overhead wires, it is found quite difficult and expensive to maintain the insulation at such a point that there shall be no appreciable loss of energy occasioned by leakage. When we consider the number of supports that must be provided for the primary wires, and the average number of converters with, perhaps, their secondaries grounded on one side that offer channels for escape, it is not to be wondered at that grounds are more the rule than the exception. Just here a grave objection to the use of very high E. M. F. comes in; it is, in plain words, that with a given insulation resistance, the higher the E. M. F. the greater the percentage of loss resulting. Suppose, for the sake of illustration, that insulation resistance between the mains of a 2,000 alternating system is 1,000 ohms, the loss would be 4,000 watts, or 5.36 electrical horse-power; while in the case of a 200-volt system—insulation resistance being the same—the loss would be 40 watts, about 1-17 of an electrical horse-power. The ratio of loss between the two systems, due to defective insulation, would therefore be as 1 : 100. This is a matter that the electrical engineer can not afford to neglect in estimating the general efficiency of a system.

To return to the safety devices and look at them with reference to their effect upon the insulation of a high tension alternating converter system, it has been admitted by an advocate of these systems in the course of this discussion that the practice of grounding one side of the local circuits throughout the systems subjected the insulation of the primary to increased strain, and was for that reason inadvisable. Let us see if it does not do more than this. We will suppose that there is a fair average insulation resistance between the primary and secondary wires of all the converters, also between the primary wires and ground. Now, whatever this may be, the result of grounding the local circuits will be to offer their conjoint resistance to ground, and in the case of a large number of converters so joined, the loss can hardly fail to be very considerable.

Another safety device, the invention of Mr. Kent, I believe, consisted of a metal plate or cover placed between the primary and secondary wires of a converter, but carefully insulated therefrom, and connected to ground. This safety device has the defect that it is purely local to the converter, and does not provide any safeguard from danger arising from crosses between the primary and secondary wires outside of the converter. It is common practice to carry both sets of wires upon the same poles, and any safety device that does not cover this point, can not be said to be perfect. Again, I hardly see how the metal shield can be made to completely envelop the primary or secondary without interfering with the action of the converter to some extent. This, however, is a matter upon which I can not speak from personal experience.

Regarding the efficiency of alternating generators as compared with continuous, it appears to be pretty generally conceded that they are about on equal footing; but in the matter of weight for a given capacity there is—unless very recent improvements have made a change—a slight difference in favor of the continuous machine. Part of this is probably due to the fact that the alternations in a continuous current armature do not take place so rapidly or frequently, and less iron can therefore be used in proportion to wire.

Theoretically there should be no trouble in operating alternating current dynamos connected in multiple arc, provided their reversals take place synchronically. Where they are driven by separate engines it is hard to see how this can be brought about.

I have not touched upon the matter of deterioration of the alternating converter system, as the time at my command did not permit me to obtain sufficient data to prove of use. Placing the wires in a high tension alternating system underground we must expect to encounter much more trouble from retardation than would be the case with high tension currents if continuous. It is possible to overcome this to a great extent by a proper disposal of the mains with relation to each other, and any iron that may lie within easy reach. But perfection in this would surely add to the cost of a plant.

During the progress of this discussion the assertion has been made that it was not good policy to put in a small plant and increase with the demands of business, and the advice given to put in a plant large enough to meet the expected increase; in answer I would say: It is a well-established fact that the maximum efficiency in operation of all steam engines is exhibited when doing full duty, and it has frequently been demonstrated that in cases where the increasing business of a manufacturer called for increased power, it would pay him better to put in several engines, increasing in power by steps as increased business demanded, even if the old engines were given away, than to put in a very large engine at the outset with the expectation that the business would soon grow up to it.

I can not help feeling that the use of converters in a system of electrical distribution is in a certain sense a step back, and is like introducing belting or gearing in mechanical work where direct application would be the wiser and more economical course. We see in modern machinery so many evidences of the truth and force of this remark that I am led to ask again, why convert?

In conclusion, it appears to be impracticable to supply any particular system in all cases, and an impartial consideration of local conditions with the general character of the distribution to be effected should guide the engineer in his choice. The matter is one that should not be lightly decided, and I am hopeful that this discussion may prove fruitful.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Overhead Wires and Street Accidents.—Asperities in the Board of Electrical Control.—Annual Election of the Electric Club.—The Forthcoming Annual Meeting of the Institute of Electrical Engineers.—The Electric Railway at Asbury Park.—An Electrical Manufactory to locate at Rahway, N. J.—Electric Lighting and Politics at Red Bank, N. J.—A New Signal Service Cable.—The Legislature and Western Union Taxes.

THE writers of the daily press are beginning to learn that the electric wires are not responsible for all the dangers of New York streets, and have recently given much attention to careless driving, by which people are killed or injured nearly every day. Attention was directed three years ago through the columns of the ELECTRICIAN AND ELECTRICAL ENGINEER not only to the accidents at street crossings, but those arising from falling signs whenever there was a heavy gale. The prediction was also made that there would be more wires overhead after the time set by law for their final burial, than there were when the act was passed. The actual condition of affairs is probably worse now than at any previous time, as no arc lighting wires have been put underground, while they have been permitted to deteriorate where originally placed, until accidents have become alarmingly frequent. The latest victim was Mayer Streiffer, a young Jewish peddler, who was killed April 15th by contact with a "dead" wire which lay across an electric light conductor, and dangled near a pole close to the sidewalk, on East Broadway.

The difficulty experienced in coercing the companies to bury their wires, crops out in the proceedings of the board of electrical control. The snow and frosts of winter have not eradicated the asperities of discussion, in which his honor Mayor Hewitt and Commissioner Gibbens take part. At the first meeting held this spring Mr. Gibbens made the Mayor angry by remarking that the latter had failed to apply the remedial legislation provided for in the law in case the companies refused to take down the poles and wires and place the latter in the conduits provided for them.

"That is a statement that is absolutely untrue," exclaimed the Mayor.

"I reiterate the statement," remarked Mr. Gibbens.

"And I say it is not true," retorted the Mayor.

"The Mayor of the city has refused to order the Bureau of Incumbrances in the Department of Public Works to take down the poles and wires"—this from Mr. Gibbens.

"The Mayor of the city has done no such thing"—this from Mr. Hewitt—"and if he has refused to enforce the law why don't you, as a good citizen, impeach him?"

"I am willing to impeach him," replied Mr. Gibbens.

The board, after some further wrangling between Mr. Gibbens and the Mayor, ordered the contracting company to go on with the incomplete work of last year, beginning with the first week in May. The plans for new work were referred to the engineer of the board.

The election of officers at the Electric Club took place on April 19th and resulted in the unanimous choice of the following gentlemen: president, Henry C. Davis; vice-presidents, E. T. Gilliland, Geo. W. Hebard, O. E. Madden and George L. Beetle; secretary, Charles W. Price; treasurer, Willard L. Candee. The board of managers consists of Theodore N. Vail, George B. Coggeshall, Henry D. Stanley, M. W. Goodyear, Cyrus O. Baker, Jr., J. N. Keller, John C. Tomlinson, Charles W. Gould, Charles W. Spear, A. H. Patterson, H. L. Storke, H. A. Reed and John A. Seely. Committee on membership, Henry Hine, George Worthington, George T. Manson, Henry D. Lyman and Lieut. F. W. Toppan. After the election dinner was served, and a report of the affairs of the club was made by president Davis.

The annual meeting and election of the American Institute of Electrical Engineers will be held at 127 East 23d street on Tuesday evening, May 15th, followed by a general meeting for the reading and discussion of papers, on Wednesday, May 16th. The growth of the business and literary work of the Institute has made it necessary to secure suitable quarters for the accommodation of its library and files. The question of an up-town or down-town location has been settled, at least temporarily, by the leasing of a commodious room in Temple Court, 5 Beekman street. It will be occupied by the secretary, and utilized for council and committee meetings, while the monthly meetings of the Institute will be held as heretofore at the house of the American Society of Civil Engineers.

The Seashore Electric Railroad at Asbury Park, N. J., is encountering renewed difficulties in its preparations for extending its line toward Ocean Beach. In order to secure a right of way, a lot of poles were dumped on Main street, but the business men along the route have prevented their being planted until after a hearing before the commissioners.

Another important electrical industry is reported as being about to locate in New Jersey. The Forest Park Association at Rahway has sold quite a large block of land to a company which is to manufacture the Johnson electric service apparatus. The use of this system for the regulation of temperature in public and private buildings, is rapidly extending in the eastern states, and its operation is so perfect that every new installation leads to an increased demand.

The question of street lighting has entered into local politics at Red Bank, N. J., where the present board of commissioners granted the privilege to the electric light company, which will begin its service this month. The gas company claims that its contract for public lighting does not expire until August 1st, and that consequently the people will be obliged to pay for both gas and electricity until that date. This knowledge has built up an opposition party to the present board, and it is expected to be an important factor at the election May 1st.

General Greely, chief of the signal service, has contracted for the laying of a new cable from Woods Holl, Mass., via the Pasque and Naushon Islands to Vineyard Haven, Martha's Vineyard.

Unusual interest has been recently directed toward the doings of the lobby at Albany. Editor John I. Platt, of Poughkeepsie, has attracted attention to himself by reason of his introduction of a bill in February last to compel the return to the Western Union and Gold and Stock Telegraph companies of about $180,000 in taxes. This bill is absolutely mandatory. Another bill introduced by Mr. Irwin directs the board of claims to hear and determine the amount, and upon due proof award such sum as was paid as state taxes, under such mistake of fact or law, or paid in excess of a tax based on the capital stock employed within the state, or paid under such unconstitutional law. It was for making suitable arrangements for this back tax legislation that Clarence Cary, Esq., presented a bill to the Western Union company for $5,000, which was declared to be exorbitant by the executive officers of that corporation.

NEW YORK, April 23d, 1888.

POINTERS.

.... IT is wrong to make people learn things that they must unlearn afterwards. A man with a wrong idea is more ignorant than if he had none at all.—*J. Swinburne.*

PHILADELPHIA.

The Electric Light Trust. — The City Lighting Contracts. — The Rapid Transit Electric Railroad Company.—The Welsbach Incandescent Gas Burner.

THE trustees of the Electrical Trust, which controls all of the electrical lighting companies in this city, held a meeting a few days ago and declared a dividend of 75 cents per share. The par value of each share is $100, and the selling price about $40 per share. This is the second dividend that has been declared by the Trust within a little over six months. The first dividend was declared on October 10, and was at the rate of $1 per share.

At the meeting of the Trust the first suggestion of one of the largest Trust deals—outside of the Standard Oil—yet attempted in this country was made. This was nothing less than a proposition to consolidate all the electric lighting companies in the United States in a Trust, so as to control all the electric lighting in the country. Propositions have been made to purchase all the certificates of the Trust in Philadelphia, and there is ample capital behind the scheme to carry it out if a satisfactory deal can be made.

It is said that the electric lighting franchises of several of the large cities of the United States have already been absorbed by this new Trust syndicate, and the chances of the absorption of the Philadelphia Trust are excellent.

The scheme does not contemplate the purchase of the franchises or companies in the small towns, but only of those in such great centres as New York, Boston, Philadelphia and Chicago. There is reason to believe that the syndicate controls the electric lighting companies in New York and Boston, in which two cities the scheme originated.

The proposition made to the Trust in this city are based upon its net earnings for the past six months. None of the members of the Trust were willing to discuss the details of the proposed deal the other day.

Director Wagner has decided to continue the contracts with the electric light companies at the present prices. When, in December last, he made a three-months' contract with the companies, he referred the bids made by them for the entire year to councils for acceptance or rejection. That body has not seen fit to take action in the matter, and the director has been compelled to assume the responsibility, as the present contracts ran out on April 1. Director Wagner says the prices are about eight per cent. lower than last year's, and most of the companies have already agreed to go on with the work, and it is believed they will. The new contracts will be prepared in time to prevent any interruption of the electric lighting of the city.

The Rapid Transit Electric Railroad Company, a newly incorporated organization of this city, recently placed upon the desks of all the city councilmen, at their special meeting, prospectuses containing a request that it be allowed the use for three months of the abandoned and disused tracks on Poplar street for the purpose of demonstrating the practicability of its plans. The motive power is electricity transmitted from a copper bar in a conduit under the track to a motor in the car. The sum of $1,000,000, payable in twenty annual installments of $50,000, is offered for the privilege of running cars over the following route: A double track from 29th street and Lehigh avenue to Ridge avenue, to 28th street, to Poplar street, thence by single track to Parrish street, to Corinthian avenue, to Brown, to 19th, to Shirley, to Francis, to Brown, to Marshall, to Wood, to Sixth, to Minor, to Fifth, to Wood, to Seventh, to Spring Garden, to 11th, to Poplar, to 28th street, and to starting point. The officers are: president, Hiram Miller; vice-president, W. A. Levering; secretary, Theodore K. Vogel; treasurer, Samuel A. Newman; directors, S. P. M. Tasker, J. B. Mencke, W. A. Levering, C. N. Apple, Lewis Eckel, Franklin Noble and Hiram Noble. These gentlemen are also the incorporators, with the addition of N. E. Janney and Crawford Spear. The request of the company was not brought formally before councils.

A private exhibition was given a few days ago of the Welsbach incandescent gas burner, a contrivance invented by Dr. Carl Auer Von Welsbach, an Austrian scientist. The burner, supplied by the flame of an ordinary gas light, gives forth an intensely brilliant illumination, equal to electricity.

The ingenious Welsbach gaslight consumes the ordinary illuminating gas in such a manner as to produce absolutely perfect combustion. It is known as the Bunsen principle of combustion, attained by heating a meshwork of metals to a brilliant incandescence, from which the illumination is radiated. It produces this result by burning about one-half the quantity of gas now required for an ordinary gas burner. If it is introduced in this city it will result in reducing the cost of gas about one-half what it is at present to consumers. The Welsbach burners are very simple, and are supplied at trifling expense. It is only necessary to unscrew the ordinary burners now used on gas fixtures and substitute a Welsbach for it. Then it becomes necessary only to turn on about half the quantity of gas to get about twice the illumination. The popularity of an article of this character is apparent without comment. A stock company has been formed to bring the Welsbach into commercial recognition, and it will soon be a commodity universally known by virtue of its own merits. In the list of stockholders and managers of the corporation are several well-known Philadelphians. The stock is $100 par, of which $30 has been paid. The officers and directors consist of:

President, A. O. Granger; secretary and treasurer, S. D. Bodine; board of directors, George Philler, William Wood, Thomas Dolan, William M. Singerly, John G. Reading, A. O. Granger, William G. Warden, W. W. Gibbs, Randal Morgan, Robert Glendenning, T. J. Montgomery, A. G. Richey; advisory committee of stockholders, Henry C. Gibson, Lemuel Coffin, William T. Carter, Joseph E. Gillingham, C. P. Helfenstein, J. B. Altemus, James A. Wright, H. H. Houston, T. Wistar Brown, William Brockie, Clayton French, Thomas Cochran, A. C. Humphreys, Morton McMichael, I. V. Williamson, Wayne McVeagh.

PHILADELPHIA, April 20, 1888.

BOSTON.

A Large Amount of Underground Work Already Accomplished.—A General Franchise Granted by the Board of Aldermen.—The Company which has Obtained the Franchise.—Conduits Considered by the Assembly Committee on Mercantile Affairs.—Electric Lighting and Insurance Discussed at the Boston Electric Club.—The New England Electric Exchange; its First Quarterly Meeting.—Professor Dolbear on the Telephone Decision.—Monthly Output of Telephones.—The First Fatal Accident at the Thomson-Houston Works.—Electric Lighting at Lynn.—Magnitude of Electric Communication between Boston and New York.

HERETOFORE speculators and inventors have kept their hands off from the streets of Boston, so far as relates to underground electric systems; at least no activity has been shown in that direction. Meanwhile, the Edison Electric Light Company have put down many hundred feet of their three-wire conductors. The Western Union Telegraph Company were the early birds, and have buried a considerable quantity of wire in wrought iron pipe. The New England Telephone and Telegraph Company have down several miles of underground wires, embraced in two styles of conduit; the first consists of iron pipes embedded in asphalt; the second is the creosoted plank conduit, with longitudinal compartments and man-holes every two hundred feet.

On the evening of the 9th inst., after transacting minor business, the board of aldermen went into a committee of the whole to consider the matter of a conduit system for wires.

After the rising of the committee and the resumption of the general session, two reports were presented; the minority of the committee holding that the city was without right to construct and maintain electric conduits or to grant franchises to others for such purposes. The majority report submitted an order, which, after some discussion, was adopted, granting

To H. E. Cobb and others an exclusive franchise to construct, establish and maintain through and under the streets of the city conduits for telegraph, telephone, electric light and power communicating wires It also provides that the board of aldermen shall determine the location in the streets through which the conduits are to pass. The petitioners agree to furnish the city free of all rent and charge accommodations for all wires now owned or controlled by the city or that may hereafter be owned or controlled by said city, and to furnish and keep in repair such wires without expense to the city, and shall pay to the city all the excess of their profits of ten per cent. of the capital actually invested, and shall allow their books and accounts to be inspected at any time by the city auditor or any person whom the board of aldermen may designate.

Work shall be begun in four months from the passage of the order. The parties shall also grant to all corporations whose wires may be required to go underground reasonable accommodations, for which a uniform price, without favor, partiality or discrimination, shall be charged. All disputes shall be referred to the board of aldermen. The parties further agree that, should the city construct a sub-way in streets where conduits shall have been laid, to take up their conduits and place them in such a sub-way at their own expense. After ten years the city may purchase the franchise. Nothing granted shall affect the Edison Illuminating Company, or prevent it from laying its own conduits, or the rights granted heretofore to any individual or company to maintain underground conduits, or the vested rights, if any, of any individual or corporation in any of the streets included in the order.

The history of this corporation, which has acquired these valuable rights from the board of aldermen, is as follows:

On December 27, 1881, the board passed an order giving to W. R. Clarke, C. W. Lewis, J. F. Shorey, Fred. Allen, A. A. Nickerson, S. O. Richardson, C. Wakefield, rights and privileges in the streets of Boston to construct and maintain wires underground. On March 24, 1887, an order was presented to the board requesting permission to transfer the above privileges to the American Conduit Co.; and on the 18th of April, 1887, an order was passed by the board authorizing the transfer. On or about the 1st of May, 1887, the mayor vetoed the measure, but the aldermen were equal to the emergency, and passed the order over the veto. The American Conduit Co. "has grown" since its first inception, and today includes several so-called systems, which have been knocking about town for a considerable time, and has a good many "friends." Meanwhile the American Conduit Co. are before the legislature to perfect their title. On the 12th inst. the assembly committee on mercantile affairs gave a hearing on the orders as to placing all electric wires underground. Messrs. H. E. Cobb, R. M. Pulsifer and F. R. Chapman were represented by Mr. S. C. Powers; the Bell telephone company by Messrs. G. A. Bruce, H. N. Shepard and F. H. Williams; the Western Union Telegraph

Company by Mr. George S. Hale; and the Spaulding Conduit Company by Hon. Henry Winn. Colonel Pulsifer advocated the proposed legislation, the arguments being substantially the same as were used before the board of aldermen and which have already been fully published. He was cross-examined at much length by the opposing counsel. The advocates for the legislation proposed submitted the following bill:

Section 1. Every company incorporated for the purpose of constructing and maintaining underground conduits or pipes, through which to conduct wires for telegraphic, telephonic and electric light and power communication, shall possess the powers and privileges, and be subject to the duties, restrictions and liabilities prescribed in this chapter.

Sec. 2. Every company may, under the provisions of the following section, construct underground conduits, under and through streets, highways and public roads, and under any waters within the Commonwealth, but shall not incommode the public use of highways or public roads, nor endanger nor interrupt the navigation of any waters.

Sec. 3. The mayor and aldermen of any city or the selectmen of any town may grant to any corporation organized under this chapter a permit to construct conduits under any streets, highways or public roads, upon such terms and conditions as they may deem necessary for the proper protection of the public, and may determine the location in such street, highway, or public road through which said conduits may run; and the mayor and aldermen and selectmen of the place through which such conduits are to be located may grant an exclusive franchise for the construction and maintenance of such conduits for a term of years, if, in their opinion, public convenience and necessity require such a franchise to be granted.

Sec. 4. The mayor and aldermen or selectmen of a place in which such conduits have been constructed may order any company maintaining overhead wires for the transmission of intelligence by electricity or furnishing electric light and power, to place its wires in such conduits, if in their opinion public opinion requires such action, and said wires can be located and operated in said conduits without material injury to the business of said companies.

Sec. 5. A company shall not commence the construction of its conduits until three-fourths of its capital stock has been unconditionally subscribed for; and the directors shall, within ten days of commencing said conduits, file in the office of the secretary of the Commonwealth a sworn statement of the subscription.

Sec. 6. A company shall not at any time contract or owe debts to a larger amount than one-half part of its capital stock actually paid in.

Sec. 7. The president and treasurer of each company shall be jointly and severally liable for all its indebtedness, in case of wilful neglect or omission on their part to comply with any of the provisions of this chapter.

Sec. 8. Every company shall construct its conduits in such a manner as shall be satisfactory to the mayor and aldermen or selectmen granting the franchise.

Sec. 9. Every company shall provide suitable accommodations for such telegraph, telephone, and electric light and power companies as may desire to place the wires owned or controlled by them in said conduits; and also for such wires as the mayor and aldermen or board of selectmen may order to be placed in said conduits.

Sec. 10. Every company constructing and maintaining such conduits may charge rent to, and collect of, telegraph, telephone and electric light and power companies, for the use of said conduits, and the mayor and aldermen or selectmen of the place where the conduits are located may fix and regulate the rates or tolls which said company shall charge its customers.

Sec 11. The mayor and aldermen of any city and the selectmen of any town may establish reasonable regulations relating to the construction and maintenance of conduits by companies overissued under this chapter.

Mr. Powers offered in print the evidence of hearings before the aldermen, the annual report of the board of electrical control of New York, etc., as establishing the feasibility and desirability of placing these wires underground, and rested the presentation of his case at this point. The committee then adjourned until the 19th, when the remonstrants will begin to submit their side of the case.

On the 27th ult., in response to an invitation extended to representatives of various electric companies to assemble and talk over equitable means for harmonizing the subject of insurance inspection and the effective installation of electric light plants desired by the different electric light companies, about fifty electricians assembled at the rooms of the Boston Electric Club. Mr. P. H. Alexander was chosen chairman. No formal votes or resolutions were passed, but an interesting discussion was carried on. It was recognized on both sides that there is a mutuality of interest, and that the highest degree of safety against fire is of money value to the electric companies in the way of reputation as well as to the insurance companies in the diminution of risk. The chief debatable points appeared to be as to the necessity of having "converters" placed outside of buildings, as the insurance companies require; as to the proper character in respect to material and size of fusible plugs, and as to the nearness to each other in which parallel lines of electric light wires may be extended. After the debate there seemed to be a pretty general recognition on both sides that until further advance is made in the art the converters had better be kept outside.

Mr. Thomas D. Lockwood spoke in behalf of the telephone wires, and thought that the several electric companies should work together in the stringing of wires, so that each should be protected from the other.

Mr. S. E. Barton, representing the New England Insurance Exchange, said that that organization will probably soon adopt a lower schedule of insurance risks for buildings of a certain class lighted by the incandescent system, that system of lighting when properly put in and subject to their inspection being recognized as making a safer risk than either gas lighting or kerosene.

An invitation having been brought to the meeting by Professor Cross to visit the electric laboratory of the Institute of Technology, and to witness the operation of the alternating system of electric lighting recently installed there, an adjournment was taken for this purpose.

At the evening session the discussion of various topics was continued, and it was voted to form an organization, to be known as the New England Electric Exchange. Officers were chosen as follows: president, P. H. Alexander, of the Sawyer-Man company; secretary, H. B. Cram, of the Bernstein company; referees, Dr. Robert Amory, Frank Ridlon and G. W. Davenport. The trustees will be the medium of communication between the members and the New England Insurance Exchange. The board is to report at a meeting to be held in April a plan under which license may be granted to employés of electric light stations, and to those employed in the wiring and installation of electric light plants.

The New England Electric Exchange held its first quarterly meeting on the 9th inst., at the rooms of the electric club on Boylston street, president Alexander in the chair. The board of referees elected at the recent meeting of gentlemen connected with electric lighting interests, at which meeting the exchange was formed, submitted a report that embodied the proceedings of that meeting, and gave an account of the several conferences held by them with gentlemen representing the fire insurance interests, in reference to the matter of licenses being granted by the exchange to persons practically engaged in the installation or operation of electric plants, with the object of inducing the insurance underwriters to recommend the introduction of electricity in preference to other means for producing artificial illumination and for power. A constitution was also submitted and adopted. The following-named officers were then elected: president, P. H. Alexander; secretary-treasurer, H. B. Cram; directors, the president and secretary-treasurer, and Messrs. Robert Amory, Frank Ridlon and George W. Davenport.

Professor Dolbear is reported as saying, apropos of the recent telephone decision, that it as a whole surprised him, not only in the parts affecting himself, but the other contestants as well. "As for the Drawbaugh people," said he, "they got more than I expected they would. I had no idea that their claim for priority of invention would be sustained by a single judge, but it seems that three out of the seven were satisfied that to Drawbaugh belongs the credit of the invention. They may well be satisfied with the decision; and I am of opinion that they were more successful than they expected to be, and, encouraged by their success, they may endeavor to have the case reopened. No such patent was ever issued before, and the patent office refuses to issue such a broad one again; but the Supreme Court will not cancel the one already issued. I have an altogether different method from Bell's, and a better one, as it is free from many defects always present in his."

The statement of the output of telephones by the American Bell company for the month ended March 20 is tabulated herewith:

March—	1888.	1887.	Increase.
Gross output	4,106	4,372	*266
Instruments returned	1,621	1.452	169
Net output	2,485	2,920	*435
Dec. 21 to March 20—			
Gross output	12,108	11,759	356
Instruments returned	5,381	5,326	55
Net output	6,727	6,425	302

*Decrease.

The Thomson-Houston Electric Company, of Lynn, record the first fatal accident at their works in West Lynn. At eleven o'clock Friday forenoon, March 31, Harry H. Levitt, twenty-two years of age, received a shock from a circuit on which there were 52 arc lamps. The electric current which passed through his body being equal to about 40 h. p., his death was instantaneous. An artificial respiration was kept up for an hour by Professor Thomson, Superintendent Rice and others, but without avail. Levitt was taking readings from two instruments which should have been placed so far apart that he could touch but one at a time. Instead of this, by his own carelessness, it is said, the instruments were placed close together. His hands were both badly burned. His home was in Philadelphia. His father is a traveling agent for the Thomson-Houston company.

The committee on manufactures reported a bill to consolidate the Lynn Gas Light Company and the Lynn Electric Lighting Company, to be the Lynn Gas and Electric Company, if they get the written consent of the gas commissioners. It is to have the rights and privileges of both the present companies, and to have a capital equal to the united capital of the two companies. The property of the new corporation is to be liable for the debts of each of the old companies.

There are usually 100 direct telegraph wires and 16 telephone wires between Boston and New York. Sixty-two of the telegraph wires belong to the Western Union company. The Mutual Union has 17, the Commercial Cable Company has 10 wires, and there are many private wires.

BOSTON, April 16, 1888.

POINTERS.

.... IN the reading room at electric club. *Member:* Where is THE ELECTRICAL ENGINEER? *Hall-boy:* He's down in the basement, sir. (A fact.)

CHICAGO.

The Alternating vs. Continuous Current Discussion at the Chicago Electric Club.—The Club Enlarges its Quarters.—Endorsement by the Chicago Electric Club of the Patent Reform Bills of the National Electric Light Association.—The Opposition Infringing Telephone Exchange at St. Louis Closed Up by Mr. Durant, General Manager of the Bell Telephone Co., of Missouri.—The Cushman Telephone Co. Favored by the Chicago City Council.—The Chicago Telephone Co.'s Building about Ready for Occupancy.—Mr. Wilson's Admirable Central Office Arrangements.—A Large Isolated Lighting Plant for the New Auditorium Building.—Removal of the Postal Telegraph Company's Offices.—The Dorsett Ordinance Vetoed at Kansas City.—Underground Wires Considered at Cleveland, Ohio.—The Ohio Valley Centennial Exposition at Cincinnati.—The Western Electric Company to Supply 200 Arc Lights for the Exhibition.—Professor Gray's Telautograph.—Another Big Telephone Scheme.—The Large Electric Light Plant at New Orleans.—The Excelsior Electric Company Secures Contract to Light the Power Station of the Chicago City Railway Co. and the Union Stock Yards.—Personal Mention: Mr. C. G. Sholes, Mr. F. E. Crawford, Mr. F. B. Badt, Mr. J. I. Sabin.—Accidental Death of Mr. G. E. Sutton.—A Western Electric Plant for Dunkirk.—The Chicago River Lighting Plant to be Doubled. Electric Street Railways.

THE third of the series of papers before the Chicago Electric Club on the subject of the Continuous Current vs. the Alternating, was read by Mr. E. P. Warner on April 2d. For the sake of discussion Mr. Warner advocated the merits of the continuous current system. At the meeting of April 16th the series of papers in the discussion was interrupted for a paper by Mr. C. H. Rudd, of the Western Electric Company, on a device for testing electric light circuits while in operation.

Professor Badt will read his paper on the Alternating System at a special meeting on April 23d, and the interest in the discussion is so lively, and the subject is one which is developing so many new features at the present time, that instead of terminating the discussion with Professor Badt's paper it has been decided to extend it by three more papers, one advocating the continuous current, another the alternating, and the last to summarize the results of the entire discussion.

The Chicago Electric Club has considerably enlarged and improved its quarters by taking in the entire floor of the building in which its rooms are located. Some of the members urged objections to the present location, but after considerable search it was decided to renew the lease of the club's present quarters with the additional rooms which were offered, for a period of two years, in the lapse of which time it is the purpose of the club to secure a commodious club house.

The following resolution was introduced by C. A. Brown at the last meeting of the Chicago Electric Club, and met unanimous approval:

Whereas, the legal committee of the National Electric Light Association has drafted bills looking to the establishing of a court of patent appeals, to the increase in the salary of the commissioner of patents and to other amendments in the patent law, as set forth in the copies of the bills hereto attached, and,

Whereas, these measures have received the approval of the National Electric Light Association and appear to us to be wise and deserving of support, now, therefore, be it

Resolved, that the secretary of the Chicago Electric Club be, and hereby is, instructed to convey to Hon. Edward Lane, Member of the House of Representatives from Illinois, and a member of the House Committee on Patents, the sentiment of the club approving these measures, and to urge a favorable action thereon by the Committee on Patents.

Mr. Durant, General Manager of the Bell Telephone Co., of Missouri, has finally succeeded in closing up what was at one time a vigorous opposition exchange in St. Louis. Inferior instruments and service had reduced the number of subscribers to about seventy. These subscribers recently turned their instruments over to the solicitors of the American Bell Telephone Co., by and with the advice and consent of the Pan Electric Telephone Co., and thus rendered it unnecessary to bring further action against them. Mr. Durant spent a day in Chicage this month.

The Cushman Telephone Co. has secured a franchise in Chicago, while the Chicago Telephone Co. has failed even to get permission to move the wires of such of its subscribers as change their residences or offices on the 1st of May. The franchise of the Cushman company, which has not yet received the Mayor's approval, limits the price to be charged for telephone service to $95 for the first year, $85 for the second year and $75 for three year contracts.

The Chicago telephone building is now about ready for occupancy, and on the 1st of May the executive offices of the Chicago and Central Union Telephone companies will be moved to that building.

Mr. Wilson claims confidently to have the best equipped central office in the world. It has numerous original features. The method of wiring and the distributing boards are particularly novel and interesting features.

One of the largest isolated electric light plants in the world will be that for lighting the new auditorium building. A part of this building is being hastened to completion now, in anticipation of the republican national convention. In the auditorium part of the structure there will be 5,000 incandescent lights, and in the offices and hotel which will occupy the rest of the block, there will be 3,600 lights.

The Postal Telegraph Co. will move to their handsome offices in the Phœnix building on the 1st of May.

The Dorsett underground ordinance in Kansas City was vetoed by the Mayor, and the council has since decided not to pass the ordinance over the Mayor's veto.

The City Council of Cleveland is considering the question of putting underground all electrical wires. Profiting by the experience of other cities the ordinances which are under consideration, and one of which will probably be passed, are conservative measures which provide for the gradual removal of overhead wires to suitable conduits underground, of the companies' own selection.

The Centennial Exposition of the Ohio Valley, at Cincinnati, has made arrangements with the Western Electric Company for the use of 200 arc lights during the summer. Efforts are being made to ensure success for this exposition, and it is expected that manufacturers of electrical apparatus will take advantage of the special inducements offered and make the electrical feature of the exposition a prominent one.

Professor Gray expects soon to give an exhibition of his perfected telautograph, which is described in one of the daily papers as follows:

"The little instrument which threatens to revolutionize both the telephone and the telegraph is in its general appearance a stand or table with duplicate parts. On one of these parts are the appliances for transmitting and the other for receiving. Each is a disc covered with a specially prepared paper. The operator writes on the paper as on an ordinary sheet, and the message is reproduced on the connected instrument. If the adjustment is perfect the chirography will be reproduced in perfect fac-simile, just as a telephone transmits the voice. The power of the instrument is equal to that of the telegraph, and a longer range of connection is possible than with the telephone. An advantage of the instrument will be that it will facilitate commercial business, and letters which are now handled by mail can be sent over the wire with the convenience of telephone transmission.

"Professor Gray developed the instrument some time ago and applied for patents. His claims were passed upon some time ago, and the only protection he seeks now is that of the old countries."

On the 23d of March there was incorporated the D'Unger Long Distance Telephone Co., of Chicago, capital stock $18,000,000, to conduct a general telephone business throughout the United States. The incorporators are K. E. Keefe, T. A. Broadbent and W. I. Copeland. This company is organized to exploit the telephonic inventions of Dr. D'Unger.

The Louisiana Electric Light and Power Co., of New Orleans, claims to have the largest electric lighting plant in the world. It operates 1,500 arc lights, and has 350 miles of circuit. The Fort Wayne Jenney system is used by this company, and an 1,800 incandescent light Slattery induction dynamo has been added to the station recently.

The contract for lighting the power plant of the Chicago City Railway Co. has been awarded to the Excelsior Electric Company. The contract calls for 77 arc lights and 155 incandescent lights. This company has also secured the contract for lighting the Union Stock Yards with 50 arc lights.

Mr. C. G. Sholes has been appointed superintendent of telegraph of the Chicago, Santa Fe & California Railway, with headquarters in this city, and his position as superintendent of the Chicago & Milwaukee Telegraph Co. will be taken by Mr. F. E. Crawford.

Mr. F. B. Badt, who has been hitherto in the service of the United States Electric Lighting Co., has recently severed his connection with that company and engaged in an enterprise which takes him away from Chicago, much to the regret of his friends. Mr. Badt is the author of the Dynamo Tender's Hand-book, a practical little treatise, the scope of which is indicated by its title, and which is meeting with much success.

Mr. J. I. Sabin, of San Francisco, stopped over for a day or two on his way east this month. He reports that the telephone business on the Pacific coast is in a prosperous condition.

Mr. G. E. Sutton, an employé of the Western Electric Company, met death in a sudden and painful manner on the evening of April 9th. He stepped into the shaft of the elevator on the third floor, expecting to find the elevator there. It had been moved, and he fell a distance of forty-five feet to the bottom and was killed instantly. He was a nephew of Jas. B. Speed, of Louisville, Ky., President of the Ohio Valley Telephone Co., and was an exceptionally bright and promising young man.

The City of Dunkirk has purchased a 60 arc light plant from the Western Electric Company.

The Chicago river plant proves so satisfactory that it has been decided by the city authorities to double its capacity.

Numerous electric railroads are being projected and constructed in the west. One of the latest contracts announced is that at Davenport, Ia., taken by the Sprague Electric Railway Motor Co. Six of the eight cars with which the road is to be equipped will be running by July 1st.

CHICAGO, April 21, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, *11 Wall street, New York city.*

"ELECTRICAL KILLING."

[91.] Would the use of the electric current for the execution of criminals debase the science of electricity? As this is a question in morals, and not one in electricity, the electrician is no better fitted to answer it than those engaged in other honorable professions or vocations. Capital punishment is right or it is wrong. If right, it cannot lower any means that may be employed to effect it. If it be "most ignoble," then it is decidedly wrong, and not even chloroform nor the cup of hemlock should be resorted to. If wrong, it is degrading not only to all helping to bring it about—sheriff, judge, jury and law makers—but to all who even approve of it. But right or wrong, the electrician has no better ground for objecting to the use of electricity than the cutler has to the use of the guillotine, the ropemaker to the method of hanging, or the physician to the use of any poisonous drug. The profession of the physician is as exalted as that of the electrician, and the vocation of the ropemaker and of the cutler just as honorable. Does any electrician abhor the thought of the use of electricity in the guiding and exploding of torpedoes for the destruction of property and human life, and the use of the electric telegraph in aiding military operations in which human beings are slaughtered by hundreds or thousands, and, what is still more horrible, by tens of thousands made cripples for life? Or does he feel that his profession is lowered because the electric current is made to do the work heretofore performed by the horse? The object of capital punishment is the direct and indirect protection of society, and this is quite as noble as the use of electrical knowledge for the purpose of making money. Let the line be drawn between right and wrong, and then let the science of electricity, if it can, serve mankind in anything and everything that is right, for right can no more degrade than wrong can elevate.

J. E. SMITH.

New York, April 7, 1888.

ANTHONY AND BRACKET'S PHYSICS.

[92].—To the objections made by Messrs. Jackson and Osmund, to the brief notice of that portion of Professors Anthony and Bracket's *Text Book of Physics*, relating to electricity and magnetism, it is but fair to say that the only claim which they make for it,—viz., that it is "useful in conjunction with a thorough course of lectures"—was clearly allowed in the review in question.

THE REVIEWER.

LITERATURE.

REVIEWS.

Electricity and Magnetism. Being the Second Volume of Elementary Practical Physics. By Balfour Stewart and W. W. H. Gee. Macmillan & Co., London and New York, 1887.

PROBABLY most students of electricity have read with pleasure and profit the excellent standard text books of Sprague, Jenkin, Thompson, Gordon and Ayrton, not to mention others, and in each of these works have been over the same general ground of principles, laws and illustrative apparatus, in the order and style peculiar to the respective author. In each, moreover, they have doubtless found some particular subjects more exhaustively discussed than in any of the others, and some things perhaps which the others did not refer to at all. It is safe to say, however, that in no one of these books, with the exception of Ayrton's which is limited in scope, can the student turn to that part relating to any particular phenomenon and find therein such a description of its principles and laws, and methods of investigating the same, that he could, without further instruction, construct suitable apparatus to accurately measure its quantities and make the required corrections for the errors necessarily inherent in nearly all physical apparatus. So true is this that some of the practicing electricians one meets, in this country at least, familiar though they may be with the ordinary text books, are unaware that their measuring instruments are subject to any structural imperfections. Of course it is understood that such extreme refinement is not always necessary, nor even desirable in some elementary works, but a failure to even hint at the facts and an inexcusable omission of references to authoritative treatises, causes many unassisted, although careful students to be left needlessly in the dark, and even well posted practical electricians often find it a difficult matter to put their hands on the treatises of the particular authorities whom they may desire to consult.

The preceding criticism does not apply, however, to the particularly excellent text book of Professors Stewart and Gee, which is the subject of this notice. Although the field covered by this work is not by any means a narrow one, there is scarcely a subject within its range which is not thoroughly explained even to its smallest details, except where abstruse demonstrations are necessary, and then suitable references to more advanced treatises are appended. It is just such a book as advanced students and practical electricians have long wished for; a book which gives complete instruction in the actual use of precise electrical measuring instruments, the laws governing their construction, the structural imperfections to which they are subject, and the mathematical corrections which may be applied to remedy them. The galvanometer, magnetometer, electrometer, and their modifications are thus considered, and the various effective methods of standardizing them and modern tests to which they may be applied are fully treated of. The construction and use of standard batteries and voltameters, and the precautions to be observed in applying them to the determination of constants are minutely discussed. Scarcely a useful method of measuring resistance, potential, current and magnetism but what is illustrated and explained in detail.

The arrangement of the subject-matter is unique and effective. The first three chapters treating respectively of Elementary Electrostatics, Magnetism—fundamental laws and experiments, and Voltaic Electricity—fundamental laws and measurements, are introductory to the remainder of the work, so that the student finds himself well acquainted with the leading principles of the science before he gets into the less elementary portions of the work. In the fourth chapter the measurement of resistance receives unusually extended treatment. The principles and details of construction of galvanometers and rheostats and their auxiliary devices are so clearly and thoroughly explained that the careful student can have no difficulty in constructing and using practical and accurate instruments. Methods of standardizing and testing the same are given, as also most of the bridge and other resistance measurements, while throughout the necessary precautions and corrections for precise work, on the necessity for which so much stress has here been laid, are succinctly pointed out. The chapter which follows on the Tangent Galvanometer, is, undoubtedly the best that has ever been written on this subject. Those who have been compelled to search through Maxwell and works of that character for the proportions and corrections for a Helmholtz double coil galvanometer, the most reliable of all magnetic instruments for current measurements, will appreciate the variety and completeness of the data relating thereto and to kindred apparatus, which is contained therein. Formulæ for the determination of current and potential from H and the dimensions of the instrument are given in full, as well as methods of calibration by volume and weight voltameters, calorimeters and known current, with the usual attentions to details.

The determination of the magnetic elements is considered in the sixth chapter, where the Kew magnetometers and dip circle are illustrated and explained, and the determination of deflections and declinations described and applied. Here, more perhaps than anywhere else, the importance of minor corrections for imperfections in the instruments employed in physical measurements becomes apparent, and it is indeed a satisfaction to find in a convenient hand-book the frequently needed formulæ which it has heretofore been necessary to obtain in their completeness from the higher mathematical treatises. Electro-Magnetism and Electro-magnetic Induction logically forms the subject of the succeeding chapter where laws and their proofs are happily described. The condenser and electrometer and their applications to electrical measurements, are carefully treated of in the eighth and ninth chapters respectively, and the book is concluded with several valuable appendixes on the Wheatstone net, electrical force, standard cells, etc.

Throughout the work are numerous well selected practical examples, and from beginning to end it bears evidence of careful selection and masterful treatment of its subject-matter.

PERIODICALS.

The Journal of the Franklin Institute for March contains an article of much interest, by Professor Edwin J. Houston, on Paillard's Non-magnetic Compensating Balance and Hair-spring for Watches. The author describes M. Paillard's method of preventing the influence of magnetism in varying the rate of watches by the use of non-magnetic alloys—palladium being the principal ingredient—for the balance-wheel, hair-spring and escapement. Liberal quotations are given from the inventor's United States patents, including tables showing the composition of several of the alloys employed. A variety of experiments are described, as made by Professor Houston, to determine the efficacy of the protection obtained by the Paillard method. Two watches were subjected to severe tests; one had the palladium alloys in the balance-wheel and in the hair-spring, and had also a non-magnetic escapement; the other had palladium alloy in balance-wheel and hair-spring and a steel escapement. The experiments consisted substantially in exposing the watches to the action of strong magnetic fields, much stronger than they would be at all likely to encounter in use. The rates of the watches were not sensibly affected. Figures are given showing ratings before and after exposure. In conclusion Professor Houston expresses his belief, based on the results of his experiments, "that a watch containing the Paillard non-magnetic compensating balance, hair-springs, and escape-movement can safely be carried into even the most intense magnetic fields without suffering any appreciable change in its rate; and that while on the person of its wearer, it cannot possibly be brought into a magnetic field sufficiently strong to alter its rate." Of the two watches tested, the one having a steel escapement—the balance-wheel and hair-spring only being non-magnetic—stopped running when placed "in a horizontal position, face upwards, between the opposite pole-pieces of a Brush, 60-light dynamo, furnishing a current of nine and one-half amperes, and feeding 41 lamps. On taking it away from the pole-pieces it was readily started again. This experiment was repeated several times." The stoppage of the watch was due, Professor Houston thinks, "to the fork coming in contact with the steel roller-table. The watch though placed in a field that stopped it was not affected sensibly in its rate when removed therefrom."

Professor Houston's experiments indicated the further conclusion, that the palladium alloy is neither paramagnetic nor diamagnetic, but entirely neutral.

"Two palladium hair-springs of different alloys were placed in a uniform field, the direction of the lines of force in which was determined by a very thin layer of iron filings. On placing the springs in various positions in the field no change in the grouping of the lines was observable. They were neither concentrated on the palladium alloys nor repelled from them; that is to say, they were neither appreciably paramagnetic nor diamagnetic."

ELECTRICAL NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF APRIL 10, 1888.

The twenty-fourth meeting of the Institute was held at the house of the American Society of Civil Engineers, No. 127 East Twenty-third street, New York, April 10, 1888, the President, Mr. T. Commerford Martin, in the chair.

The President—We have before us this evening a very interesting paper, and it is somewhat remarkable that the author should have had recently another occasion of distinguishing himself in the same line in this very room. I have no doubt that he will handle his subject this evening just as ably as he did at that time, when he had an opportunity of defending the incandescent light, in a very signal manner, against the aspersion and detraction cast upon it by certain gentlemen in the west. Mr. Howell will now give us a paper on "The Maximum Efficiency of Incandescent Lamps."

(Mr. Howell read his paper. See page 203.)

ABSTRACT OF DISCUSSION.

Mr. S. S. Wheeler—I am very glad that Mr. Howell has given us the result of these experiments just as they came out. When slight variations are seen in experiments we have greater faith in their trustworthiness.

Mr. Joseph Wetzler—I would like to ask Mr. Howell if he can base calculations of both central stations and private plants on these diagrams and results; and if so, what the method of differentiation would be for separating the income or expenses of a station which at the same time supplied both power and light.

Mr. Howell—Mathematics knows no difference between a central station and an isolated plant. Of course, there is no difference. In regard to separating power and light costs, that is a matter of bookkeeping entirely. A man must know the conditions of his plant in order to tell how much of his power to charge against his motors and how much against his light. The cost of current includes every expense incurred in operating plant, except the price of lamps. I have to treat the matter in that way, because what I am after is the ratio of cost of lamps to total cost; so I take the cost of lamps by itself, and leave everything else with the cost of current. If you know how much your lamps cost and how much your current costs you have your total expense. A lamp is a known and definite thing, and everything else I have charged against current. In operating a motor, if you get the cost of current per horse-power per hour, all you have got to do is to charge against the lamps the horse-power consumed by them, and against the motors the horse-power consumed by them; and if you know the amount of electricity used in your motors and in your lamps, the proper proportion of that will be the cost of current in each case.

Mr. C. O. Mailloux—The lamps will not remain of normal candle-power, but, like all other things they grow old and reach a point where it is a question whether they are darker than the surrounding darkness; and I would like to ask Mr. Howell whether the life of the lamp, as it is taken here in the curves, means the time at which they break or the time at which they become so dark that they no longer give the full candle-power, without increased current. It would be very interesting to know just at what point the life is tabulated.

Mr. Howell—The tests begin with new lamps.

Mr. Mailloux—Then you take the point when the lamp is new, and let it burn until it burns out?

Mr. Howell—I do.

Mr. Mailloux—By the time it gets old it is not giving the same candle-power.

Mr. Howell—It makes no difference; the law applies just as well. You use the same data on your lamps as you do in determining your law. If you find you want lamps to give maximum efficiency, you take them when new. If you made your curve by taking data of the lamps half old, you would have to do the same thing here. If you start with one point of reckoning, you have to keep it up in all your calculations and experiments.

Mr. Upton—A 16 c. p. lamp, in practice commercially, fills a certain place, and, as measured by the makers, it can be taken as a commercial unit, and it is to this that the curves are applied. Three and one-tenth watts per candle is the best efficiency for the commercial man.

Mr. Mailloux—I think the significance of what I said is not fully understood. It occurred to me, looking at the lamp as constantly varying in its light-giving power, that it would modify somewhat the curve, which refers to the cost of lamps; for a lamp of low efficiency would, other things being equal, be preferable, because it would have a more uniform candle-power and would last longer before it became dim; and, on the other hand, a lamp of very high efficiency would soon become dark and would have to be changed. It is likely that a lamp of high efficiency would have to be changed long before it had broken, and what I meant to ask was, whether the cost was to be taken at the time when the customer had got tired of it and had called for a new lamp, or whether it included the growling you would allow him to do before you change the lamp.

Mr. Howell—In practice you find it nearly universal that lamps are taken down before they break. Of course that affects directly the cost of the lamps. Of course a lamp handed to you as being useless, is thrown into the receptacle for broken lamps, and is a dead lamp; so the tests include lamps only to the point at which they become useless.

Mr. Upton—The assumption on these tables is 600 hours. That means if you get that average light out of the lamp that the curve will hold true. Now, the intention of makers of incandescent lamps—I know it is with the Edison Lamp Company—is to make lamps which for 600 hours will give their full efficiency in candle-power. After that there is no guarantee and nothing said about it. We have now a set of new lamps—a hundred of them—which had run 400 hours, and only four of the lot had broken. It had always been the intention, and always the claim, that when a lamp is blackened that it should be destroyed. You notice that the Edison claim has been for a low guarantee, and one reason for that low guarantee is that the average light of the lamp is not how long it will stand on, but how long it will keep up good commercial efficiency, and what happens to the lamp after 600 hours is of no consequence as to this. The assumption is 600 hours at $3\frac{1}{10}$ watts per candle-power. I think Mr. Howell did not call attention to figure 2. I think great consideration should be given to it. It represents, as he says, five years experience on the part of the Edison lamp people, and I remember very well that in 1879, at Menlo Park, Mr. Edison spoke a great many times of the great value such a curve would have, and also of the exceeding difficulty of getting such a curve; because you have not only to pick out a large number of lamps from the same lot and test them under normal conditions, watching them closely all the time, but to get a good curve it requires many months and even years of constantly keeping lamps burning, and this represents the full experience of the Edison Lamp Company, which, just before Mr. Howell prepared this paper, was carefully gone over, taking in all the lamps which had ever been burned, and I think it is really stated safely to be within a two per cent. error.

Mr. Wetzler—I would like to ask if the speaker has ever verified the law for the candle-power of the lamp as referred to the current passing through it.

Mr. Howell—I have not, for the simple reason that current passing through a lamp in incandescent work is not something that we talk about. We talk about the pressure on the lamp always. No, I have never verified that with reference to currents. It is a very simple thing to do.

Mr. Wetzler—If we assume the resistance of the lamp to remain constant, it evidently is the same function whether we use current or potential.

Mr. Howell—We must not assume something that is not so; the current does *not* remain constant.

Mr. Mailloux—I would like to ask Mr. Howell if he has any data, or if he knows of observations which have been made tending to show clearly the difference in life of lamps run at the same watts per candle-power, using different currents. I suppose that we are all familiar with the statement which went the rounds of the press a year or two ago, to the effect that an alternating current added life to the filament of the lamp; that a lamp run at the same watts per candle-power, at the same efficiency, with an alternating current, would last longer than a lamp run with a continuous current. If that is true, it would be very interesting to have some data as to the cause of the difference? My experience with storage batteries has shown that the life of a lamp is undoubtedly increased at the same efficiency—that a lamp running at three watts per candle-power, for instance, with storage batteries, will last much longer than a lamp running at the same efficiency from a dynamo. How much the difference is I really cannot say. Now, perhaps Mr. Howell can give us information on that subject, which would be very welcome and useful.

Mr. Howell—To determine the life of any lamp there is one absolute necessity, and that is a constant pressure. During the five years in which that curve was determined, there was always one man who did nothing else but keep the pressure constant. You can do that with a dynamo, but you cannot do it with storage batteries—you cannot in practice. I have had a good deal of experience with lamps on storage batteries, and I am perfectly willing to be criticised when I make the statement that the pressure on a storage battery plant, as ordinarily installed, varies, I think, five times as much as it does on the average dynamo circuit; and that the life of lamps on a storage battery plant, as ordinarily installed and handled, is very much lower than it is on the average dynamo plant; due to nothing else than the simple impossibility of keeping their pressure anywhere. I mean that that is a defect in their methods more than anything else. They use their lamps and charge the battery at the same time, and have no means of keeping their pressure constant, and they do not do it.

Mr. Mailloux—I only wish to add that I am very sorry we did not happen to be fooling with the same battery. Probably that is the reason why Mr. Howell has found such a great difference. It was not the same battery; it was not handled the same way.

Mr. Howell—The handling of it has more to do with it than the battery has.

Mr. Mailloux—We have found that by using suitable precautions and devices it is possible to secure as constant (if not more constant) electromotive force with a storage battery as with any other source of electricity. I freely confess that I have had no facilities for making quantitative experiments or determinations by which I could get at the exact value of the difference to which I adverted.

Mr. Howell—It just occurs to me right here that I was sent to investigate the lamps in a storage battery plant. Of course I went into the place as a stranger and asked innocent questions. In this case I got the freedom of the plant and went down to talk with the engineer. I said: "Those lamps don't look very bright; do you call that a good light?" He said: "No; that isn't any good, but you ought to be here when the engine is running."

Mr. Mailloux—When you take into consideration that a storage plant that gives nominally about two volts per cell requires from two and four-tenths to two and one-half tenths for charging, and multiply that by sixty, you can readily perceive why the light was so much brighter when running the engine.

Mr. Howell—There is no question that the possibilities of the storage battery are very great. For laboratory work, where we want a constant current, there is probably no equal to it for a short time, or probably for any time; but for practical work, as storage batteries are installed commercially, they are very far from giving a constant pressure.

Mr. Franklin L. Pope—So far as I know, no accurate experiments have been made to determine the difference in light between a lamp run at an equivalent candle-power with an alternating and with a direct current; but I may say that when I was in England, about two years ago, there was some conversation among a number of electrical engineers one evening, in which that subject was brought up, and some one—I don't recollect who, but I think it may have been Professor Forbes—speaking of a plant that had been installed in Whiteley's large establishment at the West End, and worked directly by an alternating dynamo—I think it was a Ferranti machine—made the assertion very positively that the lamp showed a longer life with an alternating current than with a direct current, and the reason put forward to explain it was that with a direct current the hot carbon was something in the condition of an electrolyte and was more apt to throw off a deposit and disintegrate than when the current was continuously reversed. But I do not know whether there is anything in that or not. I simply state it as I heard it.

Mr. Howell—I think an argument drawn from one case or a few cases of that kind is hardly to be depended on very largely, because you take the identical lamps and put them on different plants, run from straight or alternating currents, you get different results, due to different handling. It is the hardest thing that I have ever undertaken to compare the lives of lamps. Now, as showing the difficulty and the misleading effect of the local conditions in a plant, when we first started in the business we made lamps of from 90 to 110 volts, and on our isolated plants we ran lamps from 95 to 100, most of them, and those lamps were all made at once. Now the man who put in our plants, and who was in charge of the work, found a good many plants giving good results and using 97-volt lamps. He found 96, 98 and 99 were giving bad results, and he drew the conclusion that the 97-volt lamps were better than 96 and 98. He drew that inference from facts determined from two or three lamps at each time. Now the voltage of the lamp had nothing to do with it. The conditions of operating the plant affected the lives in the various cases. If the man who was getting good results from 97 and the man who was getting bad results from 96 were to change their places, they would get the same as they did before. The lives of lamps are affected by every condition of running. To draw conclusions from a few lamps is misleading.

Mr. Upton—We had another instance of the finding of the relation of lives of lamps. This came from Shamokin, Pa. By breaking off the tip of a lamp under water you can fill the lamp, and you will obtain a little bubble there. This man broke the tips off a large number of lamps and concluded the larger the bubble the longer the life of the lamp. This satisfied him until we showed him that on the size of the opening depended the size of the bubble, and when you break it in mercury you cannot see the bubble at all. I think the question of alternating current and straight current in their effect on the life of lamps is an unsettled question. All our experiments have so far indicated negative results. The life is the same whether the current be straight or alternating. I do not think there are any experiments as yet proving a material difference between the two; that is where the conditions are thoroughly watched all through. With alternating currents it is very difficult to indicate the pressure.

Mr. F. L. Pope—I quite agree with Mr. Howell, that a deduction drawn from a few experiments has little, if any, value, and I merely mentioned the incident as current talk, without attaching much importance to it. I should not be at all surprised to find, after a proper investigation—and it is a matter of no small difficulty, as Mr. Howell says—I should not be at all surprised to find that there is little or no difference.

Mr. Mailloux—In the early experiments in car lighting that were conducted by a company here with storage batteries they very quickly found that they had to increase the efficiency of the lamp, because there would not be enough energy to make a round trip. At that time the lamps of three watts per candle power were not in commercial use. They were not to be had. So this company applied to the Edison company to have some lamps made. The Edison company said that they could make them lamps of any efficiency and that they would be glad to make them, but that they would not guarantee any life at all. I was not connected with the company at the time, but I understand that is the way it happened. They took the lamps and concluded that they would risk it; they let them break. They thought that lamps were cheaper than current, especially when the current came from storage batteries, and they put the lamps on. I know that some of those lamps were in use for over three months. They not only gave full voltage, but they sometimes got above it when the battery was extra charged and care was not taken to maintain constant electromotive force. It may be that the Edison company did not consider it wise for them to use that same lamp. I think it would have satisfied the test, with a reasonable life, with their own current.

Mr. Birdsall—As regards the life of a lamp when running above voltage I have found plants which have run the old Edison lamp—a 94-volt lamp—at 115 volts, and then they would give 900 hours light, and the men did not appear to think that there was very much lamp breakage even for that excess of voltage.

Mr. Upton—As to these curves which have been put on the board to-night, Mr. Howell asked me whether we should publish these results. We discussed it and concluded it was better to publish what we could about the relations between economies and lives of lamps. The time, we concluded, had come when the public should fully recognize that the mere claim of giving two watts, or two and-a-half watts, or three watts, or whatever it is per candle, means nothing, until these claims have been verified by long practice, and we know in the lamp business that no lamps can be put upon the market unless they have a large margin over the laboratory test, or otherwise your complaints and troubles

will more than counterbalance the gain, and these curves that Mr. Howell has presented here are based, I think, safely on commercial practice, and we have chosen in this case about three watts per candle as our normal rating, and we recommend it as embodying our experience and the recommendation of the Edison company for the best commercial practice.

Mr. F. L. Pope—Mr. President, there is a great deal of uncertainty in the photometric measures of lamps. Two or three years ago we heard a great deal about the remarkably efficient incandescent lamps that had been produced in England, and a gentleman of my acquaintance got some of them and undertook a photometric investigation of them, but he was not able to get so good results as had been obtained with them in England. As it happened, I was over there not long after that and made some inquiries, and found the trouble was in the system of measurement. My friend had measured them all around the horizontal circle, and the English photometers had only measured them at one angle, and that was the way they got the results which they advertised.

The President—We have reached the usual hour of adjournment. Should there be no further discussion on this very interesting and valuable paper adjournment will be in order.

I think we all feel greatly indebted to Mr. Howell for the trouble he has taken in preparing this paper and also to the Edison company that he has been enabled, and I may say permitted, to present to us information which has been accumulated at so great cost and expense, and which must be of the utmost benefit to all who are engaged in the business and profession of incandescent lighting in this country and abroad. I am sure that these results will be noted with interest not only in America, but throughout the world, wherever incandescent lamps are used.

The meeting was then adjourned.

ANOTHER IMPORTANT TELEPHONE DECISION.

Circuit Court of the United States,—District of Arkansas.

THE AMERICAN BELL TELEPHONE CO. *vs.* THE SOUTHERN TELEPHONE CO.

BREWER, J.—

When I came here I did not expect the burden of this case to fall on me, but thought I had only come to assist my brother Caldwell here and simply to advise with him. But the circumstances were such when I arrived that it seemed necessary that I should take the sole responsibility, and that he should look after other matter pending, aside from this case. I did not want to take the case. I avoid patent cases all that I can. And yet this happened to be one of those cases involving questions to which my attention has been directed as a matter of intellectual interest for the last two or three years, and from time to time as the opinions of the various courts have been announced I have examined each opinion and studied it with interest and curiosity as to the various questions presented and passed upon.

When this bill was filed no decision had been announced by the Supreme Court of the United States, although several opinions had been promulgated by several Circuit courts, and so a good deal of the testimony taken and presented in this cause was with reference to matters which it was apparently thought might be presented for examination here. But on the 19th of last month the Supreme Court decided the question, and that decision puts out of consideration many matters that would otherwise be fair subjects for discussion.

Of course the decision in that cause is not a final adjudication as between these parties. The proceeding there was *res inter alios acta* and not conclusive upon this litigation. Many questions of fact which, as between those parties, were settled by that decision—such as the question as to the priority of discovery—are not settled as between these parties by that decision. That question is still so far open that when that court has a new case before it, if brought between other parties and upon different testimony, it may declare that Mr. Bell was not the first discoverer and inventor. Thus the Supreme Court about two years ago, after a careful investigation, sustained what is known as the "Driven well" patent, but in the next year the court declared that patent void because the testimony showed the entirely new fact of two years public use which was not in the first case. Some years ago I sustained the Glidden patent for the barbed wire fence, and it is the only patent I ever sustained. Afterwards Judge Shiras held it bad because of a prior use and invention not shown in the case before me.

But it unquestionably appears from the decision of the Supreme Court that they upheld Mr. Bell's patent, and after carefully considering its construction they gave it a very broad scope.

In the present case the claim is not for the use of a current of electricity in its natural state as it comes from the battery, but for putting a continuous current in a closed circuit into a certain specified condition suited to the transmission of vocal and other sounds, and using it in that condition for that purpose. So far as at present known, without this peculiar change in its condition it will not serve as a medium for the transmission of speech, but with the change it will. Bell was the first to discover this fact, and how to put such a current in such a condition, and what he claims is its use in that condition for that purpose, just as Morse claimed his current in his condition for his purpose. We see nothing in Morse's case to defeat Bell's claim; on the contrary, it is in all respects sustained by that authority. It may be that electricity cannot be used at all for the transmission of speech except in the way Bell has discovered, and that therefore, practically his patent gives him its exclusive use for that purpose; but that does not make his claim one for the use of electricity distinct from the particular process with which it is connected in his patent. It will, if true, show more clearly the great importance of his discovery, but it will not invalidate his patent.

An effort was made in argument to confine the patent to the magneto instrument, and such modes of creating electrical undulations as could be produced by that form of apparatus, the position being that such an apparatus necessarily implied "a closed circuit incapable of being opened, and a continuous current incapable of being intermittent." But this argument ignores the fact that the claim is, first for the process, and, second, for the apparatus. It is to be read, 1, as a claim for "the method of transmitting vocal or other sounds telegraphically as herein described, by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth;" and, 2, as for "the apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, . . . substantially as set forth." The method, "as herein described," is to cause gradual changes in the intensity of the electric current used as the medium of transmission, which shall be exactly analogous to the changes in the density of the air, occasioned by the peculiarities in the shapes of the undulations produced in speech, in the manner "substantially as set forth;" that is to say, "by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting wire itself in the neighborhood of such bodies," which is the magneto method; or "by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery," which is the variable resistance method. This is the process which has been patented, and it may be operated in either of the ways set forth. The current must be kept closed to be used successfully, but this does not necessarily imply that it must be so produced, or so operated upon, as to be incapable of being opened. If opened it will fail to act for the time being, and the process will be interrupted; but there is nothing in the patent which requires it to be operated by instruments which are incapable of making the break.

If, for instance, in this case there was presented to this court something which was absolutely new in this litigation, something that was very clear and conclusive, clearly proved beyond question as a matter of fact and entirely conclusive in its effects, then this court might refuse an injunction, notwithstanding the decision of the Supreme Court or affirming the validity and determining the scope of that patent. But in all ordinary cases on an application for a preliminary injunction the decision of the Supreme Court must be accepted as conclusive, both as to the validity of the patent and as to the question of the scope or the extent to which the patent goes. That relieves me of much labor.

I understood the counsel in their argument to state that from previous decisions it must have been expected, and that it was expected by the profession generally that the Supreme Court, if it found against the validity and priority of Mr. Drawbaugh's claim, would sustain the Bell patents as broadly sustained as they have been sustained. This may have been the expectation and belief of the bar in the east, but I am inclined to think from the discussions by several members of the bar who have given this matter investigation, that was not the expectation here, and that the belief was that if the patent was sustained and Mr. Bell decided to be the first who made the invention, the patent would be so limited in law as to make it a patent for the particular apparatus described or for the particular and limited mode which was embraced and developed in the precise apparatus shown. But I think no man can read this opinion of the Supreme Court, and no man can compare that opinion with other deliverances of the courts upon patent cases without perceiving that, in language as clear and potent as it is possible for language to be, the court has affirmed the validity of the patent, and has decided its scope without limiting it to the mere apparatus, and have held that it extends to his whole method of reproducing vocal sounds. I believe that his method as he states it in his patent, and as the Supreme Court construes it, covers the whole matter of the telephonic transmission of speech, because the essential part of it consists in the transfer to the electric current, and the transfer by that current of the vibrating motions caused by the human voice in the utterance of speech.

Let me turn now to the opinion. The Chief-Justice says:

The important question which meets us at the outset in each of these cases is as to the scope of the fifth claim of the patent of March 7, 1876, which is as follows:

The method of and apparatus for transmitting vocal or other sounds telegraphically as herein described, by causing electric undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds substantially as set forth.

That is the idea of the transmission of these sounds by means of electrical undulations which are "similar in form" to the air vibrations that constitute the sounds to be transmitted. The court continued:

The question is not whether "vocal sounds" and "articulate speech" are used synonymously as scientific terms, but whether the sound of articulate speech is one of the "vocal or other sounds" referred to in this claim of the patent. We have no hesitation in saying that it is, and that if the patent can be sustained to the full extent of what is now contended for, it gives to Bell, and those who claim under him, the exclusive use of his art for that purpose, until the expiration of the statutory term of his patented rights.

In this art—or, what is the same thing under the patent law, this process, this way of transmitting speech—electricity, one of the forces of nature is employed; but electricity, left to itself, will not do what is wanted. The art consists in so controlling the force as to make it accomplish the purpose. It had long been believed that if the vibrations of air caused by the voice in speaking could be reproduced at a distance by means of electricity, the speech itself would be reproduced and understood. How to do it was the question.

Bell discovered that it could be done by gradually changing the intensity of a continuous electric current so as to make it correspond exactly to the changes in the density of the air caused by the sound of the voice. This was his art. He then devised a way in which these changes of intensity could be made and speech actually transmitted. Thus his art was put in a condition for practical use.

In doing this, both discovery and invention, in the popular sense of those terms, were involved; discovery in finding the art, and invention in devising the

means of making it useful. For such discoveries and such inventions the law has given the discoverer and inventor the right to a patent—as discoverer, for the useful art, process, method of doing a thing he has found; and as inventor, for the means he has devised to make his discovery one of actual value. Other inventors may compete with him for the ways of giving effect to the discovery, but the new art he has found will belong to him and those claiming under him during the life of his patent.

That is, the intensity of the current was changed in accordance with the form or character of each vibration. And then again the language of the court implies, what seems to me from my study of the telephone to be a necessary physical fact, that in no other way can electricity be actually made operative to convey those peculiar vibrations. That is the main idea of the patent. There must of course be something more than the bare idea; there must be some machine to make it practically useful, but the patent is not limited to the employment of it by that particular apparatus. The court said :

"It is again said that the claim, if given this broad construction, is virtually 'a claim for speech transmission by transmitting it; or, in other words, for all such doing of a thing as is provable by doing it.' It is true that Bell transmits speech by transmitting it, and that long before he did so it was believed by scientists that it could be done by means of electricity, if the requisite electrical effect could be produced. Precisely how that subtle force operates under Bell's treatment, or what form it takes, no one can tell. All we know is that he found out that by changing the intensity of a continuous current so as to make it correspond exactly with the changes in the density of air caused by sonorous vibrations, vocal and other sounds could be transmitted and heard at a distance. This was the thing to be done, and Bell discovered the way of doing it. He uses electricity as a medium for that purpose, just as air is used within speaking distance. In effect he prolongs the air vibrations by the use of electricity. No one before him had found out how to use electricity with the same effect. To use it with success it must be put in a certain condition. What that condition was he was the first to discover, and with his discovery he astonished the scientific world."

Then the court quotes from some of the scientific commendations, and adds : "Surely a patent for such a discovery is not to be confined to the mere means he improvised to prove the reality of his conception."

It follows, and this to my mind is supreme as to the scope of the patent, that by its terms and by the decision of the court it covers the idea of the transmission of the vibrations of articulate sounds by undulatory currents of electricity.

These undulations or vibrations are the means of reproducing human speech at a distant point, becase they repeat electrically the same vibrations. The sound vibrations are, so to speak, converted into corresponding and similar vibrations of electricity, as though these forces of nature, though different, were convertible, and what was done by the one would be, and in the telephone were copied by the other. The idea was that when the vibrations created by the organs of speech acted on the electrical current they set up in the electrical force the same variations or vibrations, transferred these vibrations to the electricity, which in turn transferred them to the distant point. That is the idea on which Mr. Bell's instrument is based.

The difference between putting into the current of electricity undulations which are copies of the vibrations caused by the human voice, and using a regular and uniform current of electricity merely broken up by intermissions, or what is called a make-and-break, as it is expressed, is very clear. Take the old Morse instrument. In that the currents of electricity are uniform; they are merely made and broken, and there is nothing like any change in strength. Suppose we load each barrel of a revolver with a bullet of the same size, density and shape, and shoot one after the other, they impact upon the object on which they strike with successive blows which are uniform, systematic and regular. Where a current of water flows through a pipe, if we suddenly turn a stop-cock we simply break the current; as soon as it is opened and the water gets going, it flows again with a uniform motion, and this makes only a similar impression upon a far-off object.

But Bell's idea of the transmission of sound is that the vibrations are irregular and different for each word, somewhat as if you put a paddle in the water and wave it backward and forward irregularly. Then the wave-like motion of the water is like that of the paddle. That is Mr. Bell's idea. The wave-like changes in his current are irregular, just like the irregular to-and-fro movement in the air which produces his electrical waves. That is what the Supreme Court says his patent is for. He takes a current of electricity, which is uniform and regular, and continuous in its flow, and changes that current by the vocal impulses, such as are made by articulate speech, so that the current, instead of being simply continuous and uniform, corresponds exactly with the variations of the vibrations in the air.

Looking at it from that standpoint, it seems to me impossible to transmit human speech by electrical currents otherwise than by giving to those currents variations harmonious with and corresponding to the various vibrations of the air. It would be impossible to do it by sending regular and uniform currents merely broken up. If you should merely break up a uniform current, preserving its uniformity, it would be a physical impossibility ever to transmit speech by means of it; for it is a physical impossibility ever to transfer human speech otherwise than by getting the current itself to correspond to the peculiarities of the vibrations which constitute that speech, and which the current must transfer.

That there is in all articulate speech something that may be called a pause between one vibration and another, and that that infinitesimal pause will cause a corresponding instant of no motion or no change in the electrical current which transmits that speech is obvious. When I speak there is not in one sense an unbroken and continuous flow of sound. In every vibration of the air there is an instant when, having moved in one direction it ceases to do that and begins to move in the other; and so in an electric current which copies that vibration, there would be the same corresponding infinitesimal break and flow again. And besides that, between each sound or between each word or each syllable there is a pause in the air vibrations, and so there would be in the electric undulations which copy them. But that is not a broken current like the current of the Morse telegraph. When we speak of a continuous current in the telephone we mean a current which has such continuity as the air vibrations and motions have in speech.

It was urged at the hearing that the defendant's instrument had breaks of current which accompanied the various changes in the motion of the instrument acted on by the voice. It was said that the use of the induction coil showed that there were breaks in the currents, and also that there were two separate circuits, the primary and the secondary, and that the current did not flow and was not continuous from one into the other. Neither of these considerations are new in this litigation. Both were presented to the Supreme Court. But suppose all that to be true, just as stated. If the Supreme Court had decided that there must be only one current, and that the current must be absolutely continuous, there might perhaps be force in that contention. But the idea which the Supreme Court rested on was that of a current continuous and undulating in the sense in which I have described it, like the vibrations of the air, corresponding to its motion, and not "merely" intermittent. It would not make any difference, in my opinion, if there were half-a-dozen currents co-operating with each other so that the transmitting current took up the undulations corresponding to the air vibrations and carried them to the distant point. The idea expressed by the Supreme Court is that stated by the language of the specification—causing and employing electrical undulations "similar in form" to the air vibrations accompanying the vocal or other sounds to be transmitted. That is the idea. That is the art or method which is patented; the same variations in the electricity as in the air—similar to the changes in the air vibrations, and co-extensive with them.

To one who has read this opinion of the Supreme Court, with that view of the operation by which speech is transmitted, there can be but one conclusion as to the fact that the various instruments which are used and are said to be used by these defendants infringe. Whatever else they do or do not produce, they produce electrical changes which correspond to the vibrations and sound waves caused by articulate speech, and those are the "undulations similar in form to the air vibrations," described in the patent.

Thus far I have very little trouble in reaching a view which disposes of this part of the case.

The other question is one that is more embarrassing, and that is whether a preliminary injunction under the circumstances of this case would be proper. These defendants engaged in this enterprise in the summer or fall of 1885. This suit was brought in the fall of 1887. For two years before this suit was instituted, the defendants had been in operation and had built up a business of some 400 telephones. The fact that it had established or was establishing its business was well known to the Bell company, and still no suit was instituted for a period of two years. Under these circumstances two questions arise.

Generally a doubtful question of fact ought not to be settled on ex-parte affidavits. In this application for an injunction the case is presented on both sides by affidavits, and affidavits are not very reliable testimony. The case, it is urged, ought to wait until the witnesses could be examined and cross-examined, and only after that full investigation, which is more certain of eliciting the truth, ought an injunction to be issued. At the hearing the important question which the counsel relied upon as doubtful, was whether the process by which their instruments transmitted speech consisted in the use of undulatory waves or of the absolute make-and-break of a current which was uniform between the breaks, and they urged that that question ought not to be settled on a preliminary investigation, or by any means short of a full hearing, upon the examination and cross-examination of witnesses.

Where there is a doubtful question of fact the court will generally wait until witnesses have been produced and been examined and cross-examined. And if this case was a case which turned upon the weight to be given to the testimony of witnesses on such a subject, the argument would be forcible.

Suppose that I entered possession of a tract of real estate, and having left it, came back twenty years after, and upon the question of an injunction the defendant claims a continuous occupation, and I produce affidavits and he produces affidavits as to

whether there was actual entry and possession by each twenty years ago. That presents a question that in the very nature of things may be doubtful, and affidavits on such a matter may control the courts very little. This is a question that particularly presents a subject for cross-examination of the witnesses. But I have had enough experience in patent cases to know there never was a patent of any intricacy in which experts could not be produced on either side—men of intelligence and scientific acquirements, ability and integrity who would file their affidavits on one side or the other. But no amount of that kind of evidence as a rule will overcome what the court can clearly learn from an intelligent examination of the instruments themselves. The examination of those instruments with the explanations given by Mr. Young and Mr. Storrow, on one side and the other, in regard to the respective apparatus, is testimony that is full and competent in this case. You see the instruments, and you examine them to ascertain the process with the explanations of these gentlemen, who are fully competent to understand it. This is not a case where the investigation is surrounded with doubtful questions of fact, which could be cleared up by cross-examination of the witnesses.

Another argument urged against this motion is that a man who claims land upon which he sees his neighbor trespassing, and on which he sees his neighbor expending money, believing that it is his own, and lets him go on without opposition, may lose his right to a preliminary injunction. A man who stands by and sees his neighbor go onto his land and dig a cellar and put in a foundation and build a house, and waits from day to day, and month to month, and year to year and says nothing to restrain him from the use and waste of his money, and afterwards wants to turn round and take his money and the products of his labor and time, does that which shocks any man's sense of right. If he knew this man was using his time, labor and money to improve his property, he should have tried to restrain him; then if the trespasser still persists, it is the trespasser's own fault.

The defendants claim that the plaintiffs did not bring their suit until two years after the defendants built their exchange, and that is the fact. But no definite length of time constitutes laches. This defense always depends upon the circumstances of the case. If these defendants had proceeded to make their investment, believing that they had a right to use their telephones and believing that no claim was made to the contrary; and had been led into this condition, by inaction and silence on the part of the plaintiffs with full knowledge of what the defendants were doing, of course it would be unfair to stop them now before the case is tried in the usual way.

But in this case the fact that Mr. Bell had these patents, and that he was insisting upon his claims in the broadest extent, and as broadly as he does now, and was carrying on the litigation in several courts of the United States, and that several courts in the various circuits had confirmed its validity and its scope as he contended for it, and that a number of these cases were pending in the Supreme Court of the United States, and that most earnest and vigorous proceedings were being carried on by the Bell company to enforce its claims, and that one department of the government was affirming frauds in the patents, and was about to institute proceedings for the purpose of canceling the patent—these matters were of common knowledge. But the defendants, in the face of those universally known facts, and it is proved with actual knowledge of the existence of the litigation and the decisions, and of the fact that litigation was pending in the Supreme Court of the United States which would sooner or later be determined, entered into this business. They say they believed that the patent would be decided to be void, and that they believed that the government suit would be a protection; and I have no doubt they believed this.

If the patent had been defeated in the Supreme Court there would be no injunction and they would be free. But this was one of the matters to be determined by the court of last resort. Under those circumstances can it be said, when these suits were finally determined in the Supreme Court and Mr. Bell was sustained to the fullest extent claimed by him here, that he should be answered here by the claim that as he had waited until his rights were determined, he was too late to enforce them; and because the defendants had infringed for two years during the litigation they were watching, they should not be interfered with six months or nine months or some other time afterwards. It is the case where, to use a common phrase, a man buys into a lawsuit and must take his chances of the result. For here the defendants knew all about the litigation and what the consequence of a decision by the Supreme Court must be, and based their expectations on the belief that the litigation would terminate adversely to Mr. Bell. But it has ended in his favor.

This case is of much importance, and I have heard several days' argument on the motion and given it all the consideration possible during the whole week. It is evident from what has been said that the plaintiffs are entitled to the preliminary injunction asked for, and it is granted.

.... To do a thing correctly, it is first necessary to understand what is to be done.—*Arthur M. Wellington.*

THE PATENT REFORM BILLS INTRODUCED TO CONGRESS BY THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

A BILL

To establish a Court of Patent Appeals of the United States, and to amend sections four thousand nine hundred and eleven, four thousand nine hundred and twelve, and four thousand nine hundred and fifteen, Revised Statutes, and section seven hundred and eighty, Revised Statutes, relating to the District of Columbia.

BE IT ENACTED, *by the Senate and House of Representatives in Congress assembled:*

SEC. 1. There shall be a Court of Patent Appeals of the United States, which shall consist of a Chief Justice and four Associate Justices, who shall be appointed by the President, by and with the advice and consent of the Senate, and who shall hold office during good behavior. Any three of said Justices shall constitute a quorum.

SEC. 2. The Associate Justices shall take precedence according to the dates of their commission, or when the date of the commission of two or more of them is the same, according to their ages.

SEC. 3. In case of vacancy in the office of Chief Justice, or of his inability to perform the duties and powers of his office, they shall devolve upon the Associate Justice, who is first in precedence, until such disability is removed, or another Chief Justice is appointed and duly qualified. This provision shall apply to every Associate Justice who succeeds to the office of Chief Justice.

SEC. 4. The Justices of the Court of Patent Appeals shall receive the sum of eight thousand dollars each per annum, to be paid monthly.

SEC. 5. The Court of Patent Appeals shall have power to appoint a Clerk and a Marshal for said Court, and a Reporter of its decisions.

SEC. 6. One or more deputies to the Clerk of the Court of Patent Appeals may be appointed by the Court on application of the Clerk, and may be removed at the pleasure of the Court. In the case of the death of the Clerk, his deputy or deputies shall, unless removed, continue in office and perform the duties of the Clerk in his name until a Clerk is appointed and qualified; and for the default or misfeasance in office of any such deputy, whether in the life-time of the Clerk or after his death, the Clerk and his estate and the sureties on his official bonds shall be liable, and his executors and administrators shall have such remedy for such default or misfeasance committed after his death, as the Clerk would be entitled to if the same had occurred during his life-time.

SEC. 7. The Marshal shall be entitled to receive a salary at the rate of two thousand dollars a year. He shall attend the Court at its sessions, shall serve and execute all process and orders issuing from it, or made by the Chief Justice or an Associate Justice in pursuance of law, and shall take charge of all the property of the United States used by the Court or its members. With the approval of the Chief Justice he may appoint assistants and messengers to attend the Court, with the compensation allowed to officers of the House of Representatives of similar grade.

SEC. 8. The Reporter shall cause the decisions of the Court of Patent Appeals, made during his office to be printed and published within six months after they are made, and within the same time, shall deliver three hundred copies of the volumes of said report to the Secretary of the Interior. And he shall, in any year when he is so directed by the Court, cause to be printed and published a second volume of said decisions, of which he shall deliver in like manner and time, three hundred copies.

SEC. 9. The Reporter shall be entitled to receive from the treasury an annual salary of twenty-five hundred dollars, when his report of said decisions constitutes one volume, and an additional sum of fifteen hundred dollars when, by direction of the Court, he causes to be printed and published in any year a second volume. But said salary and compensation respectively shall be paid only when he causes such decisions to be printed, published and delivered within the time and in the manner prescribed by law, and upon the conditions that the volumes of said report shall be sold by him to the public for a price not exceeding four dollars a volume.

SEC. 10. The three hundred copies of the reports of the Court of Patent Appeals shall be distributed by the Secretary of the Interior as follows: To the Commissioner of Patents forty copies, and the balance as provided in section 683 of the Revised Statutes for the distribution of the Supreme Court reports.

SEC. 11. The Court of Patent Appeals shall hold at the seat of government one term annually, commencing on the second Monday in October, and such adjourned or special terms as it may find necessary for the despatch of business.

SEC. 12. If at any session of the Court of Patent Appeals a quorum does not attend on the day appointed for holding it, the Justices who do attend may adjourn the Court from day to day for twenty days after said appointed time, unless there be sooner a quorum. If a quorum does not attend within said twenty days, the business of the Court shall be continued over until the next appointed session; and if during a term, after a quorum has assembled, less than that number attend on any day, the Justices

attending may adjourn the Court from day to day until there is a quorum, or may adjourn without day.

SEC. 13. The Justices attending at any term when less than a quorum is present, may, within twenty days mentioned in the preceding section, make all necessary orders touching any suit, proceeding or process, depending in or returned to the Court, preparatory to the hearing, trial or decision thereof.

SEC. 14. The Court of Patent Appeals of the United States shall have appellate jurisdiction in the cases hereafter specifically provided for without regard to the sum in controversy:

1. From the Circuit Courts of the United States and from the Supreme Court of the District of Columbia in all cases touching patents, copyrights, trade-marks and labels.

2. From the Commissioner of Patents in all cases touching patentability of inventions, priority of invention among several claimants for patent upon the same invention and the judicial practice of the Patent Office, also all cases touching the registration of trade-marks or labels and the rights of conflicting claimants therefor.

SEC. 15. From and after the passage of this Act, there shall be no appeal from the Circuit Courts of the United States in cases touching patents, trade-marks, copyrights or labels, to the Supreme Court of the United States directly, but all such cases formerly appealable to the Supreme Court shall be heard on appeal by the Court of Patent Appeals.

SEC. 16. There shall be a right of appeal from the Court of Patent Appeals, to the Supreme Court of the United States in all cases which individually involves $100,000 or more, exclusive of costs; and an appeal may be taken by the defeated party, to the Sureme Court of the United States from any final judgment or decree of the Court of Patent Appeals, when the latter Court deems the questions involved to be sufficiently important and sufficiently doubtful, to justify such an appeal, and therefore consents that such an appeal be taken.

SEC. 17. All cases touching patents, trade-marks, copyrights or labels, now pending before the Supreme Court of the United States awaiting trial may, at the option of the parties interested, be transferred to and heard by the Court of Patent Appeals

SEC. 18. When any Judge of the Court of Patent Appeals, resigns his office after having held his commission as such, at least ten years, and having attained the age of seventy years, he shall, during the residue of his natural life, receive the same salary which was by law payable to him at the time of his resignation.

SEC. 19. Section four thousand nine hundred and eleven of the Revised Statutes shall be, and hereby is amended so as to read as follows: If such party is dissatisfied with the decision of the Commissioner he may appeal to the Court of Patent Appeals of the United States.

SEC. 20. Section four thousand nine hundred and twelve of the Revised Statutes shall be, and hereby is amended so as to read as follows: When an appeal is taken to the Court of Patent Appeals the appellant shall give notice thereof to the Commissioner, and file in the Patent Office, within such time as the Commissioner shall appoint, his reasons of appeal, specifically set forth in writing.

SEC. 21. That section forty-nine hundred and fifteen of the Revised Statutes of the United States is hereby repealed.

SEC. 22. That section seven hundred and eighty of the Revised Statutes, relating to the District of Columbia, is hereby repealed.

SEC. 23. All Acts or parts of Acts inconsistent with the provisions of this Act are hereby amended so as to be consistent therewith.

A BILL

To amend sections four hundred and seventy-six, four hundred and seventy-seven, of the Revised Statutes of the United States.

BE IT ENACTED, *by the Senate and House of Representatives in Congress assembled,*

That section four hundred and seventy-six, and four hundred and seventy-seven of the Revised Statutes of the United States, be hereby amended so as to read:

"SEC. 476. There shall be in the Patent Office a Commissioner of Patents, one Assistant Commissioner, and three Examiners in Chief, who shall be appointed by the President, by and with the advice and consent of the Senate. The Commissioner of Patents shall hold office for six years from the date of his appointment. All other officers, clerks and employés authorized by law for the office shall be appointed by the Secretary of the Interior, upon the nomination of the Commissioner of Patents."

SEC. 477. The salaries of the officers mentioned in the preceding section shall be as follows:

The Commissioner of Patents, eight thousand dollars a year.

The Assistant Commissioner of Patents three thousand dollars a year.

Three Examiners in Chief, three thousand dollars a year each.

.... IT has become an axiom among experienced electric station managers that the money is made or lost between the coal-shovel and the belt.—*William Lee Church.*

THE WESTERN ELECTRIC COMPANY'S NEW FACTORY.

The new factory of the Western Electric Co. in New York will occupy the south-east corner of Greenwich and Thames streets—the frontage being 119 feet on Thames street and 83 feet on Greenwich street. The building will be of light-colored brick and terra-cotta, having nine stories above the basements. The old structures on these lots are now being demolished and removed preparatory to the erection of the new factory. The Western Electric Co. will have their building ready for occupancy on the expiration of the lease of their present factory building, 70–76 Trinity Place, April 1, 1889.

Among the buildings now being torn down is one of some historic interest. It was built and occupied as a residence by Mayor Arcularius in the early part of this century. The site is well chosen, being in close proximity to the location where the company's large business has been conducted for 10 years. The new building will be fire-proof throughout, and will be constructed under the supervision of Mr. Cyrus L. W. Eidlitz, architect, who has made plans and designs combining admirable provision for factory requirements with a very imposing and tasteful exterior. The offices will, with much good sense, be located on the top floor. The building is estimated to cost about $200,000.

PERSONAL MENTION.

MR. D. H. BATES has connected himself with the Electrical Accumulator Co. as general manager of their business. Mr. Bates has won distinction as an executive officer in the telegraph service for some 20 years past, and will doubtless make as gallant and vigorous a leader in the Accumulator company's business, as he did in that of the Baltimore and Ohio Telegraph Co.

MR. GEORGE B. PRESCOTT, JR., has accepted an appointment as electrician to the Electrical Accumulator Co., and will have his office at the headquarters of that company, No. 44 Broadway, New York. His technical acquirements and extensive laboratory practice qualify Mr. Prescott admirably for the duties assumed by him in the commercial development of storage batteries.

MR. ANTHONY RECKENZAUN, after spending nearly a year in America, has returned to England. His departure will be much regretted by his American acquaintances and friends. His large experience in Europe with storage batteries and with electric traction, has been called into profitable service here in the work of Mr. Wm. Wharton, Jr., at Philadelphia, and of the Electrical Accumulator Co., of New York. His presence at meetings of electrical associations has always been welcome, while his contributions and remarks in discussion have been very useful and suggestive. It is to be hoped that Mr. Reckenzaun will return to the United States at no distant day.

THE DAFT COMPANY NOT SELLING OUT.

We are informed that there is no truth whatever in the rumor that the Daft company is about to be sold out to the Thomson-Houston company, recently published in another journal. Mr. Hawksworth, of the Daft company, authorizes us to say that there has been no offer, no negotiation, not even a thought of selling out. The Daft company proposes to take care of its own business and to hold its own among competitors.

REMOVALS.

JARVIS B. EDSON has removed from 91 Liberty street—where for 14 years he has conducted business in supplying his recording steam gauges—to No. 145 Broadway and 86 Liberty street (the old telegraph corner).

HENRY CONNETT, patent solicitor and expert, removes from Temple Court, to offices in the new Vanderbilt building, No. 132 Nassau street.

WELDING RAILS BY ELECTRICITY.

An exchange states that a Baltimore electrician has invented a method of welding steel rails by means of electricity. The ends of the rails after they are placed in the track are welded together through the application of a transformed electric current, and are afterward tempered so as to make the joint as hard as the rest of the rail. The welding apparatus is carried on the pilot of an engine or on a construction car, and it is claimed that a joint can be made in less than half a minute. The inventor proposes to thus make continuous rails a quarter of a mile in length, having expansion joints only at intervals of that distance, the rails being fastened at the centre so as to expand in both directions. This plan, if successful, would settle the great Fisher rail joint question, but the accumulated expansion and contraction in such long lengths of solid rail would be formidable.

ELECTRIC LIGHT AND POWER.

THE NASHVILLE JENNEY ELECTRIC LIGHT AND POWER CO. has been fully organized with A. L. Landis, Sr., president, and A. L. Landis, Jr., secretary and treasurer. The right of way has been granted through the streets of Nashville, and the company will be prepared to receive bids on machinery, etc., within 50 days.

THE LARAMIE ELECTRIC GAS LIGHT AND FUEL CO. is now running two 25 h. p. and one 20 h. p. and several smaller motors, all of Sprague make. They are on the 220-volt Edison circuits. The two 25 h. p. motors are driving a flour mill of 100 barrels capacity, and the 20 h. p. runs spike machines, nut pressers, bolt headers, lapping and threading machiney in a rolling mill. The three large motors earn together about $425 a month, while the rate for the smaller ones is about $15 per h. p. per month. The secretary and manager of the company is Mr. R. M. Jones.—*Electrical World.*

THE PACIFIC MOTOR COMPANY, of San Francisco, Cal., has 700 motors now in use, and is employing five circuits.

W. W. SLATTER, electrician and superintendent of the Central Pacific electric block system at Oakland, Cal., is replacing all oil lamp signals by Swan incandescent lamps on an arc circuit. There are forty trains daily running over this block after dark, and the greatest care is taken to keep all the colored lamps lighted to prevent accidents. It was very difficult to accomplish this when a strong wind was blowing. The change to the electric lights dispenses with two men to clean lamps.

THE reported negotiations for the sale of the Van Depoele company's business to the Thomson-Houston Electric Co. have been consummated.

AT Wheeling, W. Va., the board of gas trustees are about to install an electric light plant at a cost of some $20,000.

THE SCHUYLER ELECTRIC CO. has nearly completed the 200 arc light plant for the Mt. Morris Electric Light Co., of New York.

MANUFACTURING AND TRADE NOTES.

THE WESTINGHOUSE ELECTRIC CO. has declared a dividend of one and one-fourth per cent. for the quarter ending May 1st. The net earnings for the quarter are said to be between $90,000 and $100,000.

THE EDSON PRESSURE RECORDING GAUGE has been in use for some time at the Edison Machine Works, Schenectady, where a second instrument has just been ordered.

MR. WM. LEE CHURCH, of the Westinghouse Electric Co., says: "Texas is advancing in the use of electric light very rapidly. We have more central stations there than in any other state of the Union. We have only lately established stations at Houston and Marshall. The chief reason for this appears to be that the cost of coal there is considerable, which makes artificial gas accordingly expensive.

MESSRS. J. H. BUNNELL & CO. promptly recovered from the interruption attendant upon their recent disastrous fire, and are again about as busy as ever in filling orders.

THE WESTINGHOUSE ENGINE.—Very long continuous runs made by steam engines are considered rare, over a week, or several weeks being regarded as long runs. The Westinghouse engine, has, we are informed, increased such runs, in many instances to a number of months. The last public notice of a long run made by a Westinghouse engine was an instance where a certain engine ran 11 months without stopping, at a speed of 300 revolutions. The most remarkable record, however, has recently developed in the works of the Pittsburgh Gas Light Co., where a 10 h. p. Westinghouse engine ran continuously for 13 months, running at about 500 revolutions per minute, and in that time making 288,000,000 revolutions without the throttle valve being once closed, and it is still running.

POINTERS.

.... PEOPLE do not seem to realize that lamps do not behave like resistance; they flicker to some extent, especially if the carbons are thin. This makes them apparently run at a higher efficiency and break sooner.—*J. Swinburne.*

.... THE electrical support of the bird in the air is maintained on the effort of nature to form an equilibrium between the bird and the electricity of the air. Hence the utility of the electro non-conductibility of feathers. The fluid is expelled from the bird by muscular action, the elimination taking place at the multiple points of the wings and tail. The return of the electricity is prevented by the non-conductibility of the feathers. The loci of the force, that serves as a support of the bird, lie in the struggle of the electrical fluid to overcome the electrical vacuum in the bird. —*G. P. Hachenberg, M. D.*, of Texas, on "The Electro-Operations in the Flight of Birds" (written for the *Electrical Review*).—*Electrical Review*, New York, April 28.

ELECTRIC STREET RAILWAYS IN AMERICA

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horse-power; **T.**, T rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scafe; *Sec.*, Arthur Kennedy; *Supt.*, J. J. Houghton; *Eng.*, Sam'l Drescher; 4 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 250 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Supt.*, G. Johnson; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; water-power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; 5 mi.; g. 4-8½; 25 and 56 lb.; overhead cond. SPRAGUE.

Columbus, O.—Columbus Elect. Ry.—1 mi.; g. 5; 2 m. c.; underground conduit. HEART.

Denver, Col.—Denver Tramway Co.—*Pr.*, Rodney Curtis; *Sec.*, Wm. G. Evans; *Supt.*, Jno. C. Curtis; 4 mi.; g. 36; 16 and 18 lb.; 10 m. c.; sta. 125 h. p.; conduit cond. SHORT-NESMITH.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g.——: 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE. Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; 1 mi.; g. 5-2; 56 lb.; 2 m. c.; sta. 80 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1 c.; 1 m.; sta. —— h. p.; conduit cond. VAN DEPOELE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, Chas. D. Haines; *Sec.* F. H. Skeele; 1.5 mi.; g. 4-8½; 25 lb. T.; 2 m. c.; sta. 50 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Kansas City, Mo.—Kansas City Elect. Ry. Co.—*Pr.*, W. W. Kendall; *Sec.* & *Tr.*, Warren Watson; *Supt.* John C. Henry; 2 mi.; g. 4-8½; 70 lb.; 4 m. c.; sta. 80 h. p.; overhead cond. HENRY.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose: 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. VAN DEPOELE.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 48 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. VAN DEPOELE.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair Ry. Co.—*Pr.*, Theo. Evans; *Sec.*, J. W. Patterson; 2 mi.; g. 5-2½; 45 lb.; 5 c.; 5 m.; sta. 175 h. p.; overhead and conduit cond. DAFT.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt.*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. VAN DEPOELE.

Richmond, Va.—Union Pass. Ry. Co.—*Pr.*, J. T. Brown; *Sec.* and *Treas.*, J. F Barry, *G. M.*, G. H. Burt; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 375 h. p.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*. A. P. Friesman; *Supt.*, R. M. Waugh; 5.75 mi.; g. 4-8½; 30 lb.; 3c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

St. Joseph, Mo.—Union Ry. Co.—*Pr.*, Seymour Jenkins; *Sec.* and *Tr.*, A. Steinacker; *Supt.*, Chas. Wilson; 1 mi.; g. 4-8½; 52 lb.; 1 m. c.; overhead cond. SPRAGUE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Supt.* B. T. Killam; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 7 m. c.; sta. 360 h. p.; overhead cond. VAN DEPOELE.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond.; VAN DEPOELE.

Wichita, Kas.—Wich. Riverside & Suburban Ry. Co.—*Pr.*, J. O. Davidson; *Sec.*, N. G. Lee; 4 mi.; g. 6-8; 45 lb; 6 m. c.; sta. h. p.; overhead cond.

Wilmington, Del.—Front & Union St. Pass. Ry. Co.—*Pr.*, G. W. Bush; *Supt.*, S. W. Price; *Tr.*, E. T. Taylor; 1-3 mi.; g, 5-2; —— lb.; 2 m. c.; overhead cond. SPRAGUE.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.75 mi.; g. 3-6; 35 lb.; 1 c.; 2 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb. T; 1 m. c.; sta. 1,000 h. p.; overhead cond. BENTLEY-KNIGHT.

Constructing or Under Contract.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½: 45 lb.; 3 m. c.; 1 m.; sta —— h. p.; overhead cond. VAN DEPOELE.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—6 mi.; g. 4-8½; —— lb.; —— c.; —— m.: sta. —— h. p.; overhead cond. SPRAGUE.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown. VAN DEPOELE.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B Kerper. DAFT.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. VAN DEPOELE.

Elsinore, Cal.—Elsinore Lake Shore Elect. Ry. Co.—*Pr.*, D. G. Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.

Erie, Pa.—Erie City Pass. R. R. Co.—*Pr.*, W. W. Reed; *Sec.*, J. L. Sternberg; *Supt.*, Jacob Borst.

Flushing, N. Y.—Flushing & College Pt. R. R. Co.—*Pr.*, Jos. Dykes; *Sec.*, A. Herring; 4 mi.

Flushing, N. Y.—Flushing & College Point St. R. R.—*Pr.*, J. Dykes; *Sec.*, Arthur Herring; 1 mi.; storage bat's.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; 6 m. c.; overhead cond. SPRAGUE.
Lakeside, O.—3 mi.; 2 c.; overhead cond.
Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi.; g. 4-8½; 56 lb.; 10 m. c.; storage bats.
Louisville, Ky.—Central Pass. R. R. Co.—*Pr.*, B. du Pont; *Sec.*, J. C. Donigan; —— mi: g. 5.
Meriden, Conn.—Meriden Horse R.R. Co.—*Pr.*, Geo. R. Curtis; *Sec.* and *Tr.*, C. L. Rockwell; *Supt.*, D. Barker; 5 mi.; g. 4-8; 35 lb.; 12 m. c. DAFT.
Meriden, Conn.—New Horse R. R.—*Pr.*, T. J. Lathram; *Sec.* and *Tr.*, T. A. Lamb; 5 mi.; g. 4-8½; 35 lb.; 12 m.c.: overhead cond. DAFT.
Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W, Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.
New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.* E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.
New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.
Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.
Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 8 m.; overhead cond. DAFT.
Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.
Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, C. D. Haines; *Sec.* & *Tr.* F. H. Skeele; 4-5 mi.; g. 4-8½; 40 lb.; 6 m.; 6 c.;
Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.
St. Louis, Mo.—Lindell Ry. Co.—*Pr.* J. H. Maxon; *Sec.* and *Tr.* G. W. Baumhoff; —— mi.; g. 4-10; storage bats.
San Jose, Cal.—San Jose Motor Co.—*Pr.*, J. W. Rea.
Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.* A. Frothingham; *G. M.*, B. F. Killam; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; overhead cond. VAN DEPOELE.
South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.
Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.
Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; 3.25 mi.; g. 4-8½; overhead cond. DAFT.
Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—7 mi.; g. 5-2; 50 lb.; 2 m. c.; overhead cond. SPRAGUE.
Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

Notes.

THE DAFT COMPANY have taken a contract for the equipment of the Meriden Horse Railroad Co. The road is five miles long, and will run 12 cars. It is expected to have the road running in the early summer. This company also have a contract for 10 additional cars for the Asbury Park road for the coming season.

TESTS with the storage battery cars of the Electrical Accumulator Company are being made by the North Baltimore Passenger Railway Co.

THE ELIESON motor is being tried on the Buffalo Street Railroad Co.

THE MCGAVOCK AND MOUNT VERNON, an important road at Nashville, Tenn., has decided to adopt electric traction.

ELECTRICAL traction is soon to be introduced at Columbia, S.C.

THE DAFT electric road at Easton, Pa., is likely to be extended.

CONTRACTS for an electric road at Flushing, N. Y., have been given out.

THE new storage battery car of the Philadelphia Traction Company, which they claim will revolutionize the street railway service of the country, is kept under lock and key.

THE elevated lines in New York carried 158,963,232 passengers in 1887, an increase of 43,853,641, or over 35 per cent. over the figures of 1886.

THE surface roads running north and south carried in 1887, 175,204,439 passengers, a loss over the preceding year of about 5.75 per cent. Mechanical or electric traction is the only salvation for the surface lines.

The Street Railway Journal reports 1,198 miles of street railway built in the United States in 1887, and $3,601,000 expended in improvements. As much more is already under contract for 1888.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From March 20 to April 17, 1888 (inclusive).

Alarms and Signals:—*Electric Annunciator*, B. N. Botts, 379,758; *Tele-Thermometer*, F. J. Dibble, 379,766, March 20. *Electric Annunciator*, C. S. Young & G. E. Painter, 380,010. *Non-Interfering Signal Box*, F. W. Cole, 380,022. *Fire-Signal and Burglar-Alarm.* J. E. Church, 380,186. *Fire and Burglar Alarm System*, W. A. Barnes, 380,241, March 27. *Electro-Magnetic Signaling Device for Mines*, L. McK. Bullitt & O. C. Greene, 380,382. *Dust-Proof Thermostat*, A. S. Kissell, 380,394. *Semaphore Signal Apparatus*, F. Stitzel & C. Weinedel, 380,409. *Municipal Signaling*, M. Morris, 380,655, April 3. *Municipal Telegraph Apparatus*, J. C. Wilson, 380.778. *Municipal Telegraph*, same, 380,779. *Electrical Speed Indicator*, F. W. Schlepegrell, 380,824, April, 10. *Electric Bell*, F. B. Wood, 381,314, April 17.

Conductors, Insulators, Supports and Systems:—*Elevated Railroad and Conduit for Electric Wires, etc.*, A. C. Oehrle, 378,904, March 20. *Machine for Dressing Covered Electrical Conductors*, W. H. Sawyer, 380,053. *Apparatus for Threading Wires or Cords Through Flexible Tubes*, same, 380,054. *Conduit for Electric Railways*, S. D. Field, 380,103. *Electric Conductor*, E. G. Acheson, 380,157. *Manufacture of Electric Conductors*, E. G. Acheson & B. F. Anderson, 380,158. *Insulated Electrical Conductor*, W. A. Phillips, 380,295, March 27. *Machine for Covering Wire with Layers of Different Materials*, J. T. Van Gester, 380,610, April 3.

Distribution:—*System of Electrical Distribution.* T. A. Edison, 379,772, March 20; 380,101 and 380,102, March 27. *System of Electrical Distribution*, W. H. Hart & J. T. Goodfellow, 380,757. *System of Electrical Translation*, R. Belfield, 380,845 and 380,846. *Central Station for Alternate Current System of Electrical Distribution*, O. B. Shallenberger & H. M. Byllesby, 380,946. *Alternate-Current System of Electrical Distribution*, H. M. Byllesby & O. B. Shallenberger, 381,054, April 10.

Dynamos and Motors:—*Dynamo-Electric Machine*, M. Deprez, 379,689. *Regulator for Dynamo-Electric Machines*, T. A. Edison, 379,771, March 20. *Commutator* for *Dynamo-Electric Machines*, same, 379,944. *Regulator for Dynamo-Electric Machines*, C. Heisler, 379,956. *Electro-Dynamic Machine*, G. F. Card, 380,020. *Pyromagnetic Motor*, T. A. Edison, 380,100. *Alternating-Current Dynamo-Electric Machine*, C. Heisler, 380,115. *Dynamo-Electric Machinery*, F. J. Sprague, 380,144, March 27. *Dynamo-Electric Machine*, W. A. Crodus & H. M. Sutton, 380,620, April 3. *Dynamo*, H. B. Slater, 380,702, April 10. *Electric Motor*, P. Diehl, 381,222. *Means for Regulating and Controlling Electric Motors*, B. A. Fiske, 381,228. *Commutator-Brush for Electric Generators*, O. P. Loomis, 381,394. *Dynamo-Electric Machine*, R. H. Mather, 381,398. *Dynamo-Electric Generator*, E. E. Ries, 381,421. *Dynamo-Electric Machine*, J. Wenstrom, 381,451, April 17.

Galvanic Batteries:—*New Mercuric Salt for Battery Fluids*, A. Schanschieff, 379,820. *Galvanic Battery*, same, 379,911, March 20. *Galvanic Battery*, H. J. Brewer, 380,084 and 380,085, March 27. *Galvanic Cell*, W. Frishmuth, 380,430. *Galvanic Battery*, C. E. O'Keenan, 380,589, April 3. *Galvanic Battery*, H. J. Brewer, 380,855 and 380,856. *Construction of Stationary and Itinerant Electrical Batteries*, J. T. Armstrong, 380,971. *Secondary Battery*, H. H. Carpenter, 380,989, April 10. *Galvanic Battery*, C. R. B. Claflin, Jr., & J. W. Flagg, 380,336, April 17.

Ignition:—*Electric Gas Burner*, J. Y. Parke, 379,977, March 27. *Machine for Lighting and Extinguishing Gas*, C. E. Thaxter, 381,440, April 17.

Lamps and Appurtenances:—*Incandescent Electric Lamp*, T. A. Edison, 379,770. *Electric Arc Lamp*, E. R. Knowles, 379,792. *Socket and Key for Incandescent* Lamps, G. Wilkes, 379,842, March 20. *Arc Lamp*, T. E. Adams, 380,074. *Incandescent-Electric-Lamp Holder and Cut-Out*, C. Heisler, 380,114 and 380,202. *Electric Arc Lamp*, C. W. Adams, 380,271. *Electric Light and Globe Protector*, W. M. Tompkins, 380,301, March 27. *Electric-Arc Lamp*, A. Harding, 380,435. *Arc Lamp*, C. Berton, 380,545, April 3. *Reflector for Electric Lamps*, H. Purdy, 381,167, April 17.

Measurement:—*Volt Ammeter*, O. B. Shallenberger, 380,943. *Electrical-Pressure Indicator*, same, 380,944. *Electrical Indicator*, same, 280,942 and 380,947, April 10. *Electric Meter*, E. Thomson, 381,441 and 381,443. S. D. Mott, 381,480, April 17.

Medical and Surgical: *Electric Vapor Bath*, R. F. Jackson and W. R. Pope, 380,261, March 27. *Electric Belt*, C. B. Harness, 380,568, April 3. *Electro-Magnetic Spectacles*, J. T. Leighton, 381,260, April 17.

Miscellaneous:—*Plug for Making Electrical Connections*, G. Otto, 379,598. *Electro-Mechanical Movement*, J. F. McLaughlin, 379,802. *Attachment for Corn Planters*, M. Schmucker, 379,821. *Electric Heater*, C. Seiler, 379,822. *Electrical Stop-Motion for Knitting Machines*, W. Talcott, 2d, 379,832, March 20. *Induction Coil*, E. E. Ries, 380,138, March 27 *Graphophone*, C. S. Tainter, 380,535. *Electrical Time-Stamp*, C. A. Randall, 380,594 and 380,595, April 3. *Electric Cut-Out*, C. G. Perkins and J. Tregoning, 380,766. *Electrical Governor*, F. E. Prichard, 380,817. *Electrical Hand-Cord Tip*, H. J. Swarts, 380,829. *Apparatus for Examining Ores*, J. R. Williamson and W. W. Hickies, 380,842. *Recording Thermometer*, D. Draper, 380,872. *Adjustable Inductive Resistance*, same, 380,945. *Apparatus for Forming Sheets of Nickel or Other Metal by Electrolysis*, M. G. Farmer, 381,004, April 10. *Apparatus for Receiving Tickets from Ticket Printing or Numbering Machines*, J. Graham, 381,126. *Coating Metal Plates with Tin or Other Metals*, D. Edwards, R. Lewis and P. Jones, 381,226. *Regulator for Electric Currents*, E. R. Knowles, 381,254. *Electric Contact Changer*, P. C. Morse, 381,269. *Electrical Registering Device*, S. M. Pruden, 381,279. *Electric Switch-Board*, R. H. Welden, 381,303. *Electrical Coil and Conductor*, E. Weston, 381,304 and 381,305. *Apparatus for Electrolysis*, E. Hermite and C. F. Cooper, 381,372. *Reactive Coil*, E. W. Rice, Jr., 381,420. *Electrical Indicator*, A. L. Riker, 381,422. *Electro-Mechanical Device*, E. Thomson, 381,442. *Switch, Circuit Breaker, etc.* J. Von Der Kammer, 381,446. *Electric Valve Controller for Automatic Fire Extinguishers*, T. Atkinson, 381,459. *Electric Elevator*, G. C. Blickensderfer and J. K. Hallock, 381,492, April 17.

Railways and Appliances:—*Application of Electricity to Car-Lighting*, C. A. Faure, 379,567. *Apparatus for Increasing the Traction of Vehicles and Motors*, E. E. Ries, 379,815. *Electro-Magnetic Traction-Increasing Apparatus*, E. E. Ries and A. H. Henderson, 379,816. *Traction-Increasing System for Electric Railways*, E. E. Ries, 379,909, March 20. *Electric Railway*, F. M. Speed, 380,060. *Railway-Signal*, A. W. Bennett and J. M. Millen, 380,165, March 27. *Railway Signal*, J. H. Farrar, 380,316. *Underground Conduit for Electric Railways*, S. A. Whipple, 380,403. *Electrical Signal Apparatus*, J. R. DeMier, 380,646. *Electric Signal for Railway Cars*, same, 380,647, April 3. *Electric Locomotor*, S. D. Field, 380,879. *Electric Locomotive*, same, 380,880. *Contact-Making Device for Electric Railways*, F. Wynne, 381,048, April 10. *Electric Train-Signaling Apparatus*, J. R. DeMier, 381,343, and 381,344. *Electric Railway*, J. C. Love, 381,395, April 17.

Storage Batteries:—*Electric Storage Battery*, C. D. P. Gibson, 379,572, March 20. *Secondary Battery*, N. DeBernardos, 380,554, April 3. *Electric Accumulators*, J. M. Pendleton, 380,765. *Electrode for Secondary Batteries*, R. Packer, 380,922, April 10.

Telegraphs:—*Telegraph Key*, D. R. Borland, 380,310, April 3. *Static Compensator for Telegraphs*, M. M. Davis, 381,220. *Telegraphy*, Z. P. Hotchkiss, 381,246. *Dynamo-Telegraphy*, F. W. Jones, 381,251, April 17.

Telephones, Systems and Apparatus:—*Telephone Transmitter*, J. H. Irwin, Re-issue, 10,915, March 27. *Telephone Transmitter*, M. G. Farmer, 380,426 and 380,427. *Telephone*, W. D. House, 380,437 and 380,438, April 3. *Telephone Transmitter*, I. H. Farnham, 380,752. *Telephone and Signaling Circuit*, J. C. Wilson, 380,780. *Electrical Telephone*, F. DuP. Marston, 380,905. *Microphone Transmitter*, G. M. Phelps, 380,925, April 10. *Telephone Transmitter*, J. M. Graham, 381,234. *Slate for Telephone Desks*, E. T. Mueller, 381,271. *Telephone Transmitter*, E. H. Johnson, 381,369. *Circuit for Double-Stranded Telephone Switch-Board Cords*, C. E. Scribner, 381,430. *Long-Distance Connection for Multiple Switch-Boards*, same, 381,431, April 17.

THE
ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS, JR.

PUBLISHED MONTHLY AT

11 Wall Street, New York City.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies, -		.30

[*Entered as second class matter at the New York, N. Y., Post Office, April* 9, 1888.]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers.*

VOL. VII. NEW YORK, JUNE, 1888. No. 78.

NOTICE OF REMOVAL.

The offices of THE ELECTRICAL ENGINEER were removed May 1, from 115 Nassau street to 11 WALL STREET, New York.

By arrangement with the ELECTRICAL WORLD *of New York and with* THE WESTERN ELECTRICIAN *of Chicago, the publishers are enabled to offer either of those weekly journals, together with* THE ELECTRICAL ENGINEER, *for one year to new subscribers for* $5.00, *or the three journals for* $7.50.

NOTICE.

The proprietors and publishers of the ELECTRICAL ENGINEER *discontinue the title,* THE ELECTRICAL PUBLISHING CO., *from June* 1. *The business will be conducted, from that date, under the name of* THE ELECTRICAL ENGINEER. *All communications and remittances should be addressed accordingly.*

THE EDISON ELECTRIC LIGHT PATENTS.

A DECISION has been rendered by Judge Wallace of the United States Circuit Court in favor of the defendants, in the suit of the Edison Electric Light Co., against the United States Electric Lighting Co., for an injunction to restrain an alleged infringement of Edison's patent for an improvement in dynamo-electric machines. This was one of 26 suits instituted by the Edison company some three years ago against the same defendant. The importance of the decision lies in the fact that this was selected as a test case, and the result virtually determines the fate of at least a dozen more of Edison's patents, including three which relate to the incandescent lamp, and are regarded as fundamental. Instead of making answer to the bill of complaint in the case referred to, the defendants interposed a plea, contending that the patent had expired by reason of the expiration of a prior Austrian patent for the same invention. Judge Wallace sustained the plea and refused, on this ground, to grant an injunction, leaving the Edison company to take testimony, and show, if they can, that the invention of the Austrian patent is not the same as that of the United States patent, or that the Austrian patent did not expire, within the meaning of our statute, at the termination of its first year. This last point has already been twice decided in other cases, in which a similar state of facts existed, and the patents involved were adjudged to have expired. Hence it will be seen that the prospect of the Edison patents being ultimately sustained, is, to say the least, not a very encouraging one. A number of suits have been instituted against the Westinghouse Electric Co. and other defendants in which precisely the same issues are involved, and the results of which will necessarily be determined by the result in the test cases.

The attorneys who had charge of Mr. Edison's patent interests in the early stages of the development of his electric light inventions, unfortunately exhibited far more zeal than discretion in attempting to secure to their client a monopoly of electric lighting throughout the civilized world. The value of the rights and franchises which have, in all probability, been made nugatory by their ill-advised and hazardous procedure with reference to foreign patents is almost beyond calculation. It practically, at least as far as the Edison patents are concerned, throws the incandescent lamp manufacture open to the public in this country. It is certainly singular in view of the early day at which Mr. Edison entered this field of invention, and the enormous number of patents which he has taken out, that the essential features of the system should have received such inadequate protection.

THE subjoined extract from a letter written by an electric lineman to the coroner who is endeavoring to fix the responsibility for the death of lineman Murray, who was instantly killed a few days since while in the discharge of his duties, contains the unvarnished truth.

> All electric companies, since the passage of the subway law, have been doing slipshod, temporary work. There are no pains taken with any of the work in either telephone, telegraph or electric light, and the number of dead, crossed and broken wires is consequently on the increase.

Before proceeding to heap unsparing condemnation upon the heads of the electric companies, it may, however, be well to consider that their structures were erected in the streets of New York by permission of the public authorities, and to fulfill the public requirements; that by subsequent legislation this property has been practically confiscated, and outlawed. It would be singular, if, under these circumstances, the electric companies should feel disposed to spend any more money than they can help in repairing and improving property which may be rendered worthless to them at a day's notice.

This is but one of the results of hasty and ill-considered legislation in response to so-called "public opinion," manufactured by interested parties having private axes to

grind, and expounded by an untrammeled press, the conservator of our liberties, at the reasonable rate of one dollar per line. But the audience may as well keep their seats; the farce is not nearly over yet.

MAYOR HEWITT has, so to speak, shaken the dust of the subway commission off his feet. No one can blame him very much. The Mayor is not devoid of a sense of humor and has perhaps had some real enjoyment of the grotesque out of the meetings of the queer collection of persons who, by act of legislature and appointment of the Governor, masquerade as an engineering commission, and are called the Board of Electrical Control. But the fun of the thing probably proved insufficient compensation for the outrage to the sense of fitness and of the intelligent adaptation of means to ends, involved in the formation and career of the commission. Just why, toward the end of the nineteenth century, a political hack, a theatre agent and a presumptuous young attorney, should have been given charge of providing a great city—far exceeding all other cities in the scope and magnitude of its electric service—with a proper system of electric conductors underground, may become a question of some interest to the antiquarian curiosity of a distant future. However difficult the riddle may prove to the completely civilized denizens of the well governed city of two or three hundred years hence, the answer is not far to seek to-day.

CONSIDERABLE unnecessary surprise has been manifested by the unthinking, respecting the action of the New York board of aldermen in refusing permission to the Fourth avenue railway company to equip their line with electric motor cars propelled by storage batteries, owing, as the city fathers are careful to explain, to the danger arising from accumulations of electricity. But it must not be forgotten that many of the members of this body of scientists are chemists of no ordinary ability; as a matter of fact, most of them owe their positions to this very circumstance. Hence they may claim to speak with a certain authority.

The recollection of certain occurrences, not wholly unconnected with the annals of another street railway project in this city, prompts the suggestion that every vestige of danger from these batteries might possibly be removed by the judicious application, not to the batteries, but to the scientists, of a powerful solvent, vulgarly known as "boodle."

THE Institute of Electrical Engineers is to be congratulated upon its choice of Mr. Edward Weston as president for the year just begun. The honor of the election is not less to the Institute than to Mr. Weston, whose fitness to preside over a society so representative of theoretical and industrial electricity as the Institute has become will be everywhere recognized. To the retiring president, Mr. T. Commerford Martin, a heavy debt of gratitude is due for his untiring and judicious labors of the past year in furthering every interest of the organization. The published transactions and the annual report of the secretary at the recent meeting attest the work and progress of the Institute for the year just closed.

The attendance at the general meeting was very gratifying, the audience room of the Civil Engineers' Society being well filled by members and friends; many having come from distant points. All were amply repaid for their attention in the timely and instructive character of the papers and discussions, and in the opportunity for social intercourse afforded by the recess and luncheon.

For the purpose of giving the entire proceedings of the annual meeting, including all the papers read and their discussion, we increase the size of our present number.

MR. GEO. H. STOCKBRIDGE's paper on the proposed patent conrt was both timely and apt. He wisely confined himself to a single feature of the administration of the Patent Office, and by exhibiting a series of conflicting rulings and consequent changes of practice, see-sawing back and forth for some years, offered a cogent argument in support of the bill creating a court of patent appeals now before Congress, at the instance of the legal committee of the National Electric Light Association.

IF there be any prospective investors in primary battery companies on this side of the Atlantic, it will not be amiss for them to read Mr. F. B. Crocker's paper on the "Possibilities and Limitations of Chemical Generators of Electricity," read before the Institute of Electrical Engineers, and printed in our present issue. Its perusal should incline them to keep their dollars in their pockets for a while yet.

"DEAD" wires are too fast becoming *deadly*. We are glad to be able to note two instances of a systematic and thorough overhauling of circuits and removal or proper securing of all unused conductors. The Boston and Albany Railroad Co. has undertaken to clear up all wires throughout its road; and at Troy, N. Y. the electric light, the telegraph and telephone companies have united in an inspection and overhauling of all their wires, removing all superfluous and dangerous conductors. Let this good work spread. It seems not unlikely, that in some localities the expense of such work might easily be recovered in the value of unused wires taken down, to say nothing of any higher motive than economy.

OWING to the discovery of some inaccuracies in the text and illustrations of Mr. Tesla's very important paper, read before the Institute of Electrical Engineers, May 16, as given to the press and published already in several journals, we have delayed the issue of the ELECTRICAL ENGINEER for June, awaiting a revision of both text and illustrations under the direction of the author.

THE Supreme Court of the United States, before adjourning for the term, refused a motion for a rehearing in the telephone case, made by counsel for the People's (Drawbaugh) company, on the ground that no one of the judges who concurred in the majority opinion joined in the request. This may be looked upon as the final settlement of this most extraordinary controversy.

OUR very interesting contemporary, the *Progressive Age and Water Gas Journal*, now a semi-monthly, has removed its offices from Philadelphia to New York. The number for May 15th comes to us in a new and handsomer cover. No journal treating of illumination can ignore electricity. The *Progressive Age* always contains a page or two of electrical notes.

A STATEMENT which has recently been published in the newspapers, that overtures had been made by the Edison Electric Light Co. to the Westinghouse Electric Co., looking to a consolidation of interests, was at once officially contradicted in the Pittsburgh papers by the last named company. We have the best authority for saying that the story is entirely without foundation.

OWING to the pressure on our columns this month, notwithstanding an addition of 8 pages, we are compelled to omit some and defer other matter which we would be glad to print. We have to lay over till July the papers of Mr. Badt and Mr. Cutter, continuing the discussion of "Alternate *vs.* Continuous Currents" before the Chicago Electric Club.

OBITUARY.

GEORGE M. PHELPS.

"Whatever he touches he beautifies." These words were once fitly spoken by the lamented President Orton, of the Western Union Telegraph Co., of the artist-mechanician, George May Phelps, who died at his home in Brooklyn, on the 18th of May, 1888.

The memory of one who for so many years has been conspicuously identified with the progress of electro-mechanics, should receive a more fitting tribute than can be given in the necessarily brief space at our disposal.

In his personal characteristics, Mr. Phelps evinced many sterling traits of the sturdy New England ancestry from which he sprung. He was deliberate, thoughtful and reflective; but having determined upon a course of action, was persevering and persistent to the verge of obstinacy. To him difficulty presented itself merely as a thing to be attacked and overcome. To yield to it was apparently the last thing to enter his mind. With mental traits such as these, allied, as they were in the case of Mr. Phelps, with an inborn skill and delight in handicraft, the character of the man and his work could hardly have been other than it was.

Born in Watervliet, N. Y., March 19th, 1820, he early found congenial employment at Troy, N. Y., in the shop of his uncle, Jonas H. Phelps, a skillful maker of surveying and astronomical instruments. He learned the trade and acquired an unusual deftness and accuracy of eye and hand as a workman; this never left him till his physical strength broke down a few years ago—and enabled him when he found himself in charge of large shops, to take the tools from the hand of any workman—from the smith to the finisher of small pivots—and instruct him by example. At the age of 30, we find him carrying on a modest business, making models and light machinery, on his own account, in the same city. In 1852, the era of vigorous competition between the rival telegraphic systems of Morse, Bain and House, was at its height, and the difficulty of getting instruments manufactured as fast as they were needed, was becoming, by reason of the limited number of skilled workmen then in the country, a very serious one. The type-printing telegraph of Royal E. House a marvel of ingenuity and efficiency, for that day, but complicated and costly in its construction, could only be made in New York, and at one establishment, the limited output of which was quite inadequate to meet the requirements of the service. Struck with the unusual skill exhibited in some specimens of the handiwork of Mr. Phelps, the managers of the "House line" urged him to undertake the difficult task of manufacturing their apparatus. Accordingly the firm of Phelps & Dickerman was formed, the new partner supplying the additional capital needed, and the work was successfully prosecuted for some years. In 1856 the House lines fell into the hands of the New York, Albany and Buffalo (Morse) Co., and the use of the printing instruments was discontinued. But as it turned out, the last word in printers had not been said. A new apparatus, based upon a principle wholly unlike that of House, had been conceived and partly worked out by David E. Hughes, then a teacher of music in Kentucky. While yet in an inchoate condition, but obviously possessing great potential merits, the invention was taken up by that restless and energetic promoter of telegraphic schemes, D. H. Craig, who succeeded in selling it at a round price to a group of New York capitalists, among whom was the late Peter Cooper. These men at once organized a telegraph company, principally, as it would seem, in order to utilize their purchase. This was the inception of that vigorous and successful enterprise, the American Telegraph Co., which in 1856, purchased the Phelps & Dickerman factory, and installed Mr. Phelps as its superintendent, having already placed Hughes's invention in his hands, to be adapted by him to the exacting requirements of the commercial telegraphic service.

In 1857 the new instrument made its advent, and at once met with deserved favor. In reorganizing the original machine, Mr. Phelps had retained the fundamental conception of Hughes, the unintermittent and synchronous rotation of the transmitter of the sending, and the printing wheel of the receiving station, and as a necessary consequence, printing from the wheel while in rapid motion; but to this he had added two improvements of his own. One of these was a "corrector" by which the angular position of the type-wheel was automatically readjusted to correspond with the transmitter, at the printing of each letter, a feature essential to the completeness of the original conception; the other was an electro-magnetic speed-governor, of extraordinary simplicity and effectiveness. By a process of gradual evolution and adaptation, this instrument became the celebrated "Combination printer," an apparatus which from the threefold point of view of simplicity of construction, elegance of design, and effectiveness of performance, stands unrivaled in the annals of telegraphy. Even Mr. Phelps's subsequent invention—the motor printer—while perhaps justly regarded as one embodying a still higher degree of ingenuity, and even of distinct originality of conception, fails to impress one, in the same degree, with that indefinable something which characterizes the masterpiece, alike in art, literature or mechanism; the attainment of the most marvellous results by the simplest and apparently the most obvious expedients. As an example of consummate skill in mechanical design, this apparatus, in the opinion of the writer, stands unapproached in its department of technology.

In 1860, the American company removed the factory to Brooklyn, N. Y. In 1866, it passed into the hands of the Western Union Telegraph Co., and was subsequently removed to New York. Under the fostering care of president Orton, who was ever solicitous to effect improvements in the apparatus and methods of telegraphy, it grew into an extensive establishment. After the death of Mr. Orton, in 1878, a change of policy was inaugurated, which ultimately resulted in the sale of the factory to the Western Electric Manufacturing Co. During all these years, and it need scarcely be said, they were busy and fruitful ones, Mr. Phelps remained at his post as the superintendent and chief mechanician. Not one of all the diversified products demanded by the rapid progress and extension of the telegraph into new and varied fields of useness went forth which did not bear the unmistakable impress of his individuality. For however high Mr. Phelps may take rank

as an inventor, or as a skilful artisan, it was nevertheless as a designer that the intellectual side of his character found its freest scope and its most complete expression. While we think the Combination printer must be conceded to be his masterpiece, yet the stock-printer or "ticker" is a scarcely less striking example of his constructive genius. Originally planned for effective and hard service, its slowness of operation and barbaric clumsiness of design had been somewhat ameliorated by Edison, but it remained for Phelps to transform it into the thing of grace and beauty it is to-day, and at the same time to augment its working capacity many fold. The standard American Morse relay of the present day, is another simple but eminently characteristic example of his skill in the adaptation of novel, convenient and tasteful designs to old devices, which will be best appreciated by veteran telegraphers familiar with the "Clark" and "Cleveland" relays of a former day.

Mr. Phelps was somewhat reserved in manner and sparing of speech. Beneath his reticence there lay, nevertheless, a quiet kindliness and geniality, which will long be remembered by his associates and friends. A strong sense of humor, that unfailing friend of serious thinkers and workers, abode with him always.

Since Mr. Phelps retired from active business some four years since, it has been a source of regret to his many friends that impaired health has incapacitated him from enjoying fully the competence and leisure which he had so well earned, and which his passionate fondness for music and for the natural sciences, so eminently fitted him to appreciate. But although feeble in body, his mental faculties remained unclouded and his spirits buoyant to the last. He passed peacefully away, after a short illness, leaving to his family the precious inheritance of a good name, and the memory of a useful and high-minded life.

Mr. Phelps leaves a wife, a son, one of the editors of this journal, and a daughter. F. L. P.

OBSERVATIONS.

THE observer was asked a few days ago, "in what book could information be found regarding the *occultation* of hydrogen by palladium?"

. . .

THE Boston traveler has unearthed a saying of Emerson which is worth reproducing; here it is :—"Many years ago, before the civil war, Emerson fairly predicted the telephone. 'By new arts,' he wrote, 'the earth is subdued and we are on the brink of new wonders. The sun paints; *presently we shall organize the echo,* as we do now the shadow.'"

. . .

It is rather curious as one takes his walks abroad, to note the very wide-spread impression that the phonograph is an electrical device.

Its relationship to Mr. Edison, coupled with the identity of one of its functions with that of a telephone receiver seems to have given it a kind of brevet rank among electric appliances, which without doubt, will now be confirmed, since Mr. Edison has added an electromotor to make the wheels go round.

. . .

As to primary batteries, it appears that Great Britain is not to bear away all the honors. One need not go outside of New York to hear of a new primary battery—recently devised by Mr. Hussey. The published description which I have seen of this new battery is a meagre one, but coupled with the report of results, it reminds one of the famous request made every morning by the sister of the narrator of the Thousand and One Nights, the doomed sultana Scheherazade, "*Tell me sister, one of those tales you tell so well.*" The reader of the said published description and report of results is told ;—*Imprimis;* that the battery is open or closed.—

Item: that it is of the porous cup style, using *plain water,* which avoids the bother of placing salts in the jar.

Item: that there is no local action.

Item: that one cell placed on short circuit for 158 hours showed at the beginning of the test two and one-half amperes of current, and at the end three amperes.

Item: that it never polarizes, but uses up all the elements without waste.

Item: that it will maintain over one volt E. M. F. when on either open or closed circuit.

But the reader is not told what the original internal resistance of a battery set up with a porous cup, and "plain water" is; nor is it quite made clear how an E. M. F. of one volt can, with the same mild liquid, develop a current at the start, of two and one-half amperes, unlessthe rule $C \times R = E$ no longer holds good; since by a simple calculation we find the internal resistance under these conditions should be but .4 of an ohm; which of course is, under the circumstances, out of the question.

It is quite conceivable whatever the value of the current may be, that it should be greater at the close of the 158 hours of short circuiting than at the beginning, for supposing the positive element to be zinc, some soluble salt of that element will doubtless have formed *ad interim,* which will materially have lowered the internal resistance.

In the meantime, electricians may be excused for doubting the stated value of the original current; and most of us will continue to hold to the old fogy belief, that while zinc is employed for the positive element, economical considerations if no other, will preclude the successful competition of primary batteries with dynamos or secondary batteries in the fields which the latter now occupy; and it is hard to see a much brighter outlook if we substitute potassium, sodium, or magnesium. *Festina lente,* is a good motto for intending investors in primary battery stocks.

. . .

VOLUME xxii of the Encyclopædia Britannica has just been delivered to subscribers in the United States. One may venture the belief that it is to persons interested in the application of electricity to the useful arts, the most interesting volume yet issued; since it contains not only excellent articles upon the telegraph and the telephone, both written by Thomas Gray, B. Sc., F. R. S. E., but also a carefully written and valuable article on electrical traction by J. R. Ewing, Professor of Engineering, University College, Dundee.

The article on telegraphy gives a brief historical sketch of the art, a rapid resume of the principal methods, and devotes considerable space (as befits an author in a sea-girt isle) to submarine telegraphy. The space devoted to the telephone is exceptionally well filled, and it is hard to believe that it could have been done better, or more correctly. The principal credit is, in accordance with history and established fact, awarded to Professor A. Graham Bell; while Edison, Berliner, Gray and others are equitably and fairly dealt with. The author considers also the principal forms of carbon transmitters, the photophone and phonograph, and handles with great ability that utilization of the telephone which has proved to be the most important, viz.: the telephone exchange.

It is interesting to note that in the traction article, much dependence is placed by the author, in the American electrical journals, an involuntary tribute to their general reputation for giving exact and full information. Almost the only authorities referred to are the *Electrical Review*, ELECTRICAL ENGINEER and *Electrical World* of New York, and the "Electro-motor and its Applications," by Martin and Wetzler.

. . .

AT a recent meeting, at New York, of the executive committee of the National Electric Light Association, so it is recorded, the opinion was expressed by Dr. Moses, and others, that the "dead wires with which the air in our cities is filled" were responsible for the major part of the accidents to human life which have occurred. This opinion seems to have been concurred in by all hands, evidently being regarded as an inspiration. One does not wish to say that there are no dead wires, or that dead wires are not to be held partly responsible for some of the casualties. Yet it is painfully evident that many accidents have occurred, simply because the covering which has been chiefly employed for electric light wires is totally inadequate for its work, namely, the insulation of the wire. While it may be a correct statement that no durable first-class insulating covering

has as yet been devised, it would seem to be at least equally true, that much better coverings than those usually provided, are fully as durable, and that a dread of increased expense has made light supplying corporations woefully lax in this matter. Another and very obvious reply is that currents are not dangerous unless they are produced by a high E. M. F, and that if the number of arcs on a circuit are reduced materially the E. M. F. could also be reduced. Is it not, therefore, a duty, *if it be true that sufficient insulation cannot be provided*, to reduce the work per circuit, and consequently the E. M. F., and as a further consequence, the danger?

. . .

SOME time ago, we read a great deal, or at all events we had a great deal to read, about an electro-magnet of enormous size, made out of the muzzles of two cannon, and energized by the operation of a dynamo. The chronicled achievements of this magnet reminded one of the fabled loadstone mountains of Sinbad the sailor, which drew all the nails out of any unlucky vessel approaching within a league of its dreadful shore. It may be confessed that the writer of these lines said to himself "*cui bono?*" as he read of this wonderful magnet. It appears, however, that the idea has been adopted by the managers of rolling mills, and that by applying electro-magnets of moderate size to hydraulic cranes, ingots and other large masses of iron weighing as much as 800 pounds, are lifted with ease, and controlled simply by letting the current on and off. The observer has in former times worked in a rolling mill, and gladly welcomes this idea as being both feasible and useful.

. . .

ALL have heard of, and some of us have seen electric hair and flesh brushes, which are proved to be electric, by their ability to deflect a little compass needle, sold with them for the purpose. The unbeliever it is true, avers that there is nothing electric about these brushes, and that the deflection of the needle is caused by a magnet concealed in the back of the brush. Such is the incredulous nature of the unregenerate.

To these electrical marvels must now be added—"Electro-Magnetic Spectacles"—and as additional evidence of their surpassing value to the human race, they are patented (see U. S. Patent 381,260, April 17, 1888, to John Taylor Leighton, of Edinburgh). A pair of metal plates, one of which must be electro-positive to the other, are united by a coiled insulated wire twisted round the connecting piece and press upon the two sides of the bridge of the nose. The moisture of the flesh acts chemically upon these plates, thus forming a voltaic battery, the internal resistance of which is composed chiefly of the flesh and cartilage of the nose. The current so generated exercises a curative and strengthening influence on the eyes, temples, nerves, and muscles in connection therewith.

. . .

AKIN to the above, is the following, to which the "*Telegraphic Journal and Electrical Review*, London, kindly accords a free advertisement. One Mr. Pottage, of Edinburgh, sells to persons having more money and faith, than common sense, bottles of something which he calls "vegetable electricity" of various colors. The inventor of this remarkable article is a count—Count Mattei—and Pottage, who is a homeopathic chemist, is his agent. These colored electricities are warranted to be a cure for all diseases, totally eclipsing Holloway's Pills or Edison's Polyform.

Truly, as the only Barnum once said, "people love to be humbugged."

It may indeed be that Mr. Pottage is something of a Jacob, but where, in this electrical age, in America at least, shall Esaus be found simple enough to barter their birthright for such a mess of pottage.

POINTERS.

.... AN electric system is far less dependent upon its conductors than a cable railway is upon its rope.—*R. W. Blackwell.*

.... INACCURATE calibration is a much more common fault in the various instruments in market than bad design.—*J. Swinburne.*

.... IF you can calculate that you are selling your power at the same rates you are selling light, then if you can make 10 per cent. by selling current four hours per day, you can make 2½ times as much by selling current 10 hours per day.—*H. Mc I. Harding.*

.... WE have a patent system which is by far the best in the world. . . . The result of the patent law of this country has been the development of industries of such great magnitude that it has been copied in the laws of all nations.—*Wells W. Leggett.*

.... WE have proved beyond question that the alternating current can be put underground and can be put in lead covered cables without any danger of loss of current. If the direct wires cannot go underground, the alternating can.—*T. Carpenter Smith.*

.... IT is clear that high pressure, particularly if accompanied by rapid alternations, is not destined to assume any permanent position. It would be legislated out of existence in a very brief period even if it did not previously die a natural death. —*Edward H. Johnson.*

.... YOU must not try to get at the work which is being done on an alternating current circuit simply by multiplying the volts by the current; because there is a difference between the available current and that implied by the expressed electromotive force.—*Prof. George Forbes.*

.... I THINK if the gentlemen who are trying underground wires will simply shut their dynamos down regularly, by either short-circuiting the armature or shunting the field circuit, they will do away with a great deal of this punching holes in cables.—*T. Carpenter Smith.*

.... THE faults that occur in properly wired houses are few and far between. Out of those that do occur, 99 out of every 100 are due to switches, cut-outs, flexible cords and fittings, and therefore it is in simplifying and perfecting these that care should be taken.—*G. L. Addenbrooke.*

.... AS soon as the Americans get hold of anything that will work, they apply it. All the improvements in dynamos and in motors have practically been rejected on this side of the Atlantic. We seem to make the improvements for the Americans to make money out of.—*W. M. Mordey.*

.... THE most valuable men are the men of ideas; men who bring to light new facts in the material world; men who enlarge the boundaries of human knowledge, increase the resources of man and the means of enjoyment, and reduce the labor required to satisfy his wants.—*Chauncey Smith.*

.... I WELL remember when Faraday—who, I am sure, would be delighted, if he were living now, to witness the perfection which has been attained—saw the first dynamo at the premises of the Trinity House in 1856, he exclaimed "This was my child, but you have made a man of it.—*Sir James Douglas.*

.... ANYBODY who has been to America, and knows anything about American installations, will corroborate me in saying that the electric light machinery as made in the shop is perfection, but the putting up of it is such as would not pass muster in the worst of our English installations.—*R. E. Crompton.*

.... THE alternating current, while it is in mild doses of from 100 to 300 volts intensely more disagreeable than the direct current of the same voltage, when it comes to 1,000 volts or more, is very much less dangerous to life. I make this statement with the more confidence that I have tried them both.—*T. Carpenter Smith.*

.... IN an arc station you know about what your light is going to be. If you know your load is going to be 500 h. p., you can start your engine at pretty nearly its full load. There the big engine is undoubtedly the most economical. But in an incandescent station there is no regulation as to the amount of load.—*T. Carpenter Smith.*

.... AN immense amount of nonsense has been said and written on the subject of fire risks from electricity. These risks are so infinitesimal when installations are carried out by men who know their business, that it makes us electrical engineers lose patience when we hear the interminable discussions arising out of them.—*R. E. Crompton.*

.... MECHANICAL engineers are hardly aware of the enormous future before this new industry of electrical engineering. They hardly appreciate that it has got out of the region of small telegraphic instruments. The plant my firm are using for turning out modern electrical appliances is more like that used for planing armor plates.—*R. E. Crompton.*

.... THE best proof of economy in the use of converters is, that a test of the power expended in running a dynamo at its normal E. M. F., with its circuit closed through the primary coils of its full complement of converters, is the same as when the primary circuit is entirely open, within the ordinary limits of error of measurement.—*O. B. Shallenberger.*

ARTICLES.

WHAT IS THE SPECIFIC RESISTANCE OF COPPER?

BY GEORGE B. PRESCOTT, JR.

It is sometimes important to know the true resistance of pure copper, and every one who has had recourse to the text books for the purpose of ascertaining the specific value is aware that not only are the figures given in various arbitrary and inconvenient units, but has discovered, moreover, that if reduced to a common standard the values are discordant. In many cases no authority for the value used is mentioned, and in every instance where one is given, so far as my knowledge goes, it is attributed either to Matthiessen, or to Jenkin, who merely tabulated the results of Matthiessen's experiments.

Now, as Dr. Matthiessen conducted his experiments while a member of the committee of the British Association, which was appointed to determine upon a practical standard unit of resistance, the report of that committee[1] ought to give, authoritatively, the value of Matthiessen's determination. It seems, however, that Dr. Matthiessen devoted himself more particularly to ascertaining the permanency and relative resistances of the metals and alloys than to determining their specific resistance; so that, oddly enough, throughout the six reports made by the committee the only reference made to the absolute resistance of any of the metals or alloys is found in the third report, in a table showing the relative values of the proposed units of resistance. In this table the unit proposed by Matthiessen is *one English standard mile of pure annealed copper wire $\frac{1}{16}$ inch in diameter at* 15.5° *C., and having a resistance equal to* 13.59 B. A. *ohms.* This specific value for the resistance of copper has been extensively adopted, and is the basis of a table of the properties of copper wire by the writer, published in THE ELECTRICIAN AND ELECTRICAL ENGINEER four years ago, and also of the tables of the British Board of Trade and American standard gauges, which have since been promulgated.

In later tables more precise and scientific definitions of units and specific values have been employed, and specific resistance is now usually expressed in legal microhms between opposite faces of a centimeter cube or cubic inch of the material at 0° *C.* Happening to compare the tables of specific resistances which are published in the two recent and excellent text books by Professor Ayrton and by Professors Stewart and Gee, respectively, I observed that even they did not agree in their value for copper. Ayrton gives the specific resistance of pure annealed copper at 0° *C.* as

1.599 legal microhms per cubic centimeter =
.6292 " " " " inch.

While Stewart and Gee give the values as

1.616 legal microhms per cubic centimeter =
.6357 " " " " inch.

On looking further through a large number of electrical text books and pocket-books I found in the majority of cases that the specific resistance of pure copper was given as 9.718 B. A. ohms for a wire one foot long and one one-thousandth of an inch in diameter at 0° *C.*

In the report of the British Association Committee there is published, as an appendix, a series of "Cantor Lectures" on the subject of "Submarine Telegraphy," by Fleeming Jenkin. In the fourth lecture is a table of the specific resistances of metals and alloys calculated from Matthiessen's experiments, giving the values in foot-mils, foot-grains, etc., and this is the table which has been so extensively copied in most of the text books. Correcting Matthiessen's standard mile unit to the foot-mil dimensions as given by Jenkin gives

$$1 \text{ foot mil at } 15.5° \, C. = \frac{13.59 \times 62.5^2}{5280} = 10.054 \text{ B. A. ohms.}$$

1. Edited by Fleeming Jenkin, and published in 1873.

Using Dr. Matthiessen's formula to correct for the difference in temperature, viz.:

$$R = r\,(1 + at + bt^2).$$

In which R = the resistance at required temperature.
r = " " " given "
a = a constant number = + .003824.
b = a " " = + .00000126.
t = the number of degrees difference between the two temperatures, then

$$R = \frac{10.054}{1 + (.003824 \times 15.5) + (.00000126 \times 15.5^2)}$$
= 9.49 B. A. ohms at 0° *C.*

From which it follows that Jenkin's value is about 2.3 per cent. higher than Matthiessen's standard.

In order to fully understand the differences which exist in the published values of the specific resistance of pure annealed copper wire, it will be convenient to reduce the figures given above to the legal ohm and cubic inch units, assuming that one B. A unit = .9889 legal ohms. Then

$$\text{Jenkin's standard} = \frac{9.718 \times .9889 \times .7854}{12 \times 1000^2} = .629 \text{ legal mi-}$$

crohms per cubic inch, and Matthiessen's standard

$$= \frac{9.49 \times .9889 \times .7854}{12 \times 1000^2} = .6142 \text{ legal microhms per cubic}$$

inch.

It will thus be seen that Professor Ayrton and the majority of authors have accepted Jenkin's calculations, and that in standard wire tables Matthiessen's own unit has been taken as a basis; while Stewart and Gee, who state no authority, have a figure even higher than Jenkin's. Kohlrausch, I believe, quotes Matthiessen with even a lower figure than that given here, while intermediate values are to be found here and there.

The difference between the two references in the B. A. report will, probably, account for much of the confusion as to Matthiessen's value for the specific resistance of copper, particularly as both are attributed to him. I am inclined to think the lower figure nearer the true one, as it agrees more closely with the results of my own measurements.

SOME EXPERIMENTS ON A SPRAGUE TWO HORSE-POWER MOTOR.

BY FRANK P. COX, B. S.

(Johns Hopkins University.)

Leakage.—A single turn of wire was taken around one of the magnet limbs and a similar turn around the armature, which was turned until the plane of this coil was horizontal. A ballistic galvanometer was then connected with the turn around the field. Upon making the current around the field a throw of the needle is obtained which is proportional to the number of lines of force passing through this limb of the field. Twice this throw will, therefore, be proportional to the total intensity of the field. In a similar manner the number of lines of force passing through the armature is obtained. The ratio between these give the per cent. of the lines through the armature. The remaining lines representing the leakage. The throw of the galvanometer was noted upon making and also upon breaking the current through the field. Six such pairs of observations were taken and the mean used. The results follow:

Galvanometer connected to coil around the field.

Current made.	Current broken.	Mean.
304	314	309
302	312	307
303	340	321.5
332	339	335.5
333	336	334.5
331	336	333.5

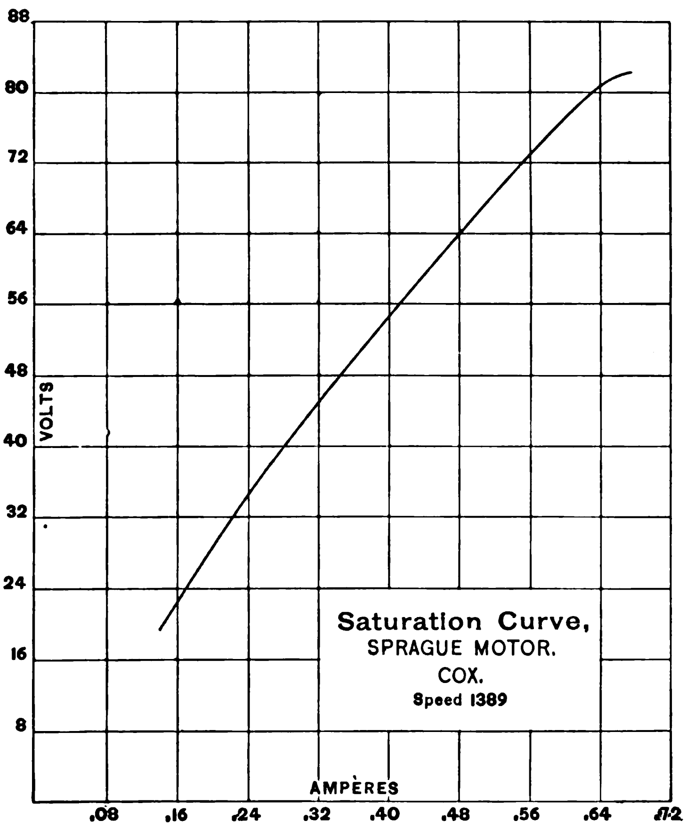
Mean for one magnet limb........................ 323.5
Mean for both magnet limbs.................... 647

Galvanometer connected to coil around armature.

Current made.	Current broken.	Mean.
366	376	371
364	374	369
363	373	368
362	370	366
359	369	364
360	370	365

Mean for armature.............................. 367
Per cent. of useful lines........................ 57%
Per cent. leakage.............................. 43%

Distribution of leak.—A coil of four turns was placed under a pole-piece. One-fourth the deflection obtained gives us the leak off the back of that pole-piece, and twice that the leak due to backs of pole-pieces. A turn of wire was taken around the bed plate and near the pole-pieces. Twice the



deflection obtained represents the leak due to the bed-plate. It should be remembered that the bed-plate and lower pole-piece are one casting.

Leakage from backs of pole-pieces.

Current Made.	Current broken.	One-fourth mean.
214	223	54.6
212	218	53.8
206	212	52.3
204	211	51.9
208	212	52.5

Mean for one pole-piece........................ 53
Mean for two pole-pieces........................ 106
Per cent. of leak................................ 16.4%

Leakage from bed-plate.

Current made.	Current broken.	Mean.
76	79	77.5
76	77	76.5
76	76	76
75	76	75.5
74	76	75
75	77	76

Mean for one end................................ 76.1
Mean for two ends.............................. 152.2
Per cent. of leak................................ 23.5%

Thus 39.9% leakage is accounted for from an observed leakage of 43%. The remainder may be accounted for by lines of force from one pole-piece to the other, external to the armature; from sides of pole-pieces, etc., etc.

Saturation of field.—The armature of the motor was disconnected and the current through the field changed after each of the readings following. The armature was rotated at a constant speed and the volts developed with different currents through the field were measured.

The potential of the exciting current was measured in place of the current itself, because a considerable change of potential corresponds to a slight change in the current. The resistance of the field was measured and found to be 167.5 ohms, from which was calculated the current.

Revolutions of armature 1389.

Volts of exciting current.	Amperes of exciting current.	Volts developed.
23.70	14	19.83
38.79	23	32.76
56.89	34	46.52
62.06	37	50.10
64.65	38	52.58
71.98	43	57.75
77.58	46	62.06
81.89	49	64.65
87.49	52	68.00
94.82	57	73.70
102.15	61	77.70
107.75	64	80.17
112.06	67	81.89
114.22	68	83.61

Saturation begins at 112.06 volts, or .67 amperes, so that in actual working the field is just below saturation.

A constant current of 15.92 amperes was then passed through the armature, the field being separately excited at 110 volts. The pulley on the armature shaft was bolted to the table on which the motor rested, and the leakage determined for different positions of the brushes which were shifted one commutator bar for each reading. A different ballistic galvanometer being used, it was necessary to repeat the readings for the field.

Field.

Made.	Broken.	Mean.
72	75	73.5
71	75	73
72	75	73.5
74	75	74.5
70	78	74
73	73	73

Mean for one limb............................ 73.6
Mean for two limbs............................ 147.2

Armature.

	Made.	Broken.	Mean.	Leak.
1st position	127	126	126.5	141
2d "	114	116	115	219
3d "	98	99	98.5	331
*4th "	80	83	81.5	446
5th "	64	66	65	558
6th "	52	53	52.5	644

Different currents were then passed through the armature with brushes in 4th position, and the leakage determined. The field was separately excited at 110 volts.

Armature.

Made.	Broken.	Mean.	Current.	Leak.
80	81	80.5	14.85	453
79	81	80	9.38	456
80	81	80.5	5.48	453
81	82	81.5	2.66	446
79	79	79	1.39	463

Efficiency.—Two efficiency tests were made; the first with practically the current and potential called for by the Co; the second with approximately 1 h. p. work being done.

* The 4th position is the one where the brushes rest when the motor is working.

Full load—Revolutions of motor, 1548.

Volts	110.39
Amperes	15.47
Electrical horse-power	2.27
Mechanical horse-power	1.69
Efficiency	744

Half load—Revolutions of motor, 1576.

Volts	110.39
Amperes	11.37
Electrical horse-power	1.65
Mechanical horse-power	1.1
Efficiency	.667

EFFECT OF CHLORINE ON THE ELECTROMOTIVE FORCE OF A VOLTAIC COUPLE.[1]

BY DR. G. GORE, F. R. S.

IF the electromotive force of a small voltaic couple of unamalgamated magnesium and platinum in distilled water, is balanced through the coil of a moderately sensitive galvanometer of about 100 ohms resistance, by means of that of a small Daniell's cell plus that of a sufficient number of couples of iron and german silver of a suitable thermo-electric pile (see Proc. Birm. Philos. Soc. vol. iv. p. 130), the degree of potential being noted, and sufficiently minute quantities of very dilute chlorine water are then added in succession to the distilled water, the degree of electromotive force of the couple is not affected until a certain definite proportion of chlorine has been added; the potential then suddenly commences to increase, and continues to do so with each further addition within a certain limit. Instead of making the experiment by adding chlorine water, it may be made by gradually diluting a very weak aqueous solution of chlorine.

The minimum proportion of chlorine necessary to cause this sudden change of electromotive force is extremely small; in my experiments it has been one part in 17,000 million parts of water;[2] or less than one 7,000th part of that required to yield a barely perceptible opacity in 10 times the bulk of a solution of sal-ammoniac by means of nitrate of silver. The quantity of liquid required for acting upon the couple is small, and it would be easy to detect the effect of the above proportion or of less than one 10,000 millionth part of a grain of chlorine in one-tenth of a cubic centimeter of distilled water by this process. The same kind of action occurs with other electrolytes, but requires larger proportions of dissolved substance.

As the degree of sensitiveness of the method appears extreme, I add the following remarks. The original solution of washed chlorine in distilled water was prepared in a dark place by the usual method from hydrochloric acid and manganic oxide, and was kept in an opaque well-stoppered bottle in the dark. The strength of this liquid was found by means of volumetric analysis with a standard solution of argentic nitrate in the usual manner, the accuracy of the silver solution being proved by means of a known weight of pure chloride of sodium. The chlorine liquid contained 2.3 milligrammes or .03565 grain of chlorine per cubic centimeter, and was just about three-fourths saturated.

One-tenth of a cubic centimeter of this solution (No. 1) or .003565 grain of chlorine was added to 9.9 cc. of distilled water and mixed. One cubic centim. of this second liquid (No. 2) or .0003565 grain of chlorine was added to 99. cc. of water and mixed; the resulting liquid (No. 3) contained .000003565 grain of chlorine per cubic centim. To make the solutions (No. 4) for exciting the voltaic couple, successive portions of one-tenth or one-twentieth cc. of No. 3 liquid were added to 900 cubic centimeters of distilled water and mixed.

I have employed the foregoing method for examining the states and degrees of combination of dissolved substances in electrolytes, and am also investigating its various relations.

1. Read before the Royal Society, May 3, 1888.

2. As one part of chlorine in 17,612 million parts of water had no visible effect, and one in 17,000 million had a distinct effect, the influence of the difference, or of one part in 500,000 millions, has been detected.

PROTECTION OF THE HUMAN BODY FROM DANGEROUS CURRENTS.[1]

BY PATRICK B. DELANY.

SINCE the object of reading a paper before this society should be the enlightenment of members on the subject under consideration by the presentation of facts developed by experimentation or of theories supported by a reasonable amount of investigation, I must apologize for my delinquency in both respects, and trust to the kind indulgence of the society in making a few suggestions with a view of eliciting information and opinions from those whose experience and familiarity with the subject enables them to speak with authority.

I allude to what are considered dangerous currents and their effect on the human body. That there is danger in handling conductors conveying high tension currents must be generally admitted. The question, therefore, is, can fatal results from such currents be wholly or partially averted? All will agree that with proper care on the part of the companies and intelligent co-operation on the part of employés, but little would be heard of the danger of electric currents. But companies are economical and employés are careless. Familiarity with danger breeds contempt for it. This is exemplified almost daily in every department of industry. A new man in a powder mill will exercise the greatest care and observe all the rules of the establishment faithfully. In a few months the same man will smoke a pipe over an open powder keg.

Protection is necessary principally for those who through carelessness or ignorance fail to protect themselves. It has been claimed that there can be no such thing as an accident —that nature has none, and that all so-called accidents are simply the results of miscalculation, bad judgment or carelessness. But it must be remembered that the vigilance of the most alert will sometimes relax, and this to them is the moment of danger.

Realizing that something should be done to protect dynamo men and wire handlers from injury from powerful currents, I, a few years since, invented a device for shunting the vital parts of the body. Partly on account of a pressure of business in other branches of electricity, but principally owing to a hesitancy in bringing out a device about the efficacy of which there seemed to be some doubt, its introduction to scientific criticism was delayed until a few weeks ago. As the references made to the question in the electrical papers have failed to elicit an expression of opinion satisfactory to any degree, it has been deemed advisable to bring the subject before this meeting.

The question to be determined is, to what extent a wire of practically no resistance, extending from one wrist to the other and bound around the wrists in numerous convolutions, so as to make good but not uncomfortable contact, will protect the vital parts of the body from fatal injury when it is placed in the path of a dangerous current through contact at the hands. It is claimed by some that the current having once entered the muscles, veins and tissue at the hands, will not leave the arms at the wrists and follow the shorter path of the wire, but will confine its course to the arms and body alone. The other opinion is that the greater portion of the current received at the hands will leave the arms at the wrists and follow the wire. The problem seems a difficult one to solve. So much depends on the condition of the person at the time of receiving a shock, a

1. Read before the American Institute of Electrical Engineers, May 16, 1888.

large number of tests would be necessary to arrive at results which would afford a safe basis for calculation. A few years ago Dr. Stone, connected with one of the London hospitals, made a series of interesting experiments upon patients afflicted with various ailments, with a view of determining whether or not fluctuation in their physical condition affected the electrical conductivity or resistance of their bodies. The results proved, according to my recollection, that great changes took place in the electrical resistance of the patients experimented upon from day to day, and that there was a direct influence manifested by the rise and fall of different diseases upon the electrical conductivity of the body as a whole or in part. An account of Dr. Stone's experiments was published in *Nature* at the time. But while the experiments were most valuable for the purpose for which they were intended, they throw but little light on the subject of dangerous currents and protection from fatal injury.

Last September, there was published in the *Electrical Review*, of London, a paper on "Shocks from Alternating Currents," by Mr. G. L. Addenbrooke, who for some time previous had charge of the Grosvenor Gallery installation, where a primary current of 2,500 volts was constantly employed. While no one had ever come in contact with both mains at once, the writer stated that even if such an accident had happened he was "by no means prepared to assert that the result would undoubtedly be fatal." "Indeed," says he, "I rather incline to the opinion that if the subject of the shock were healthy, and the circumstances under which he received it were favorable, the chances are he would survive."

I cannot make out what Mr. Addenbrooke means by receiving 2,500 volts under favorable circumstances. It seems to me, if they are received at all, the circumstance could not be other than unfavorable. Mr. Addenbrooke himself received a severe shock, and as he speaks from experience, I quote his account of how it affected him: "The primary effect of the passage of the current through the body is, of course, to contract the muscles. The amount and persistence of this contraction depend on the quantity of the current flowing, or, as it is usually designated, *the intensity* of the shock, and varies from a simple twitching of the limbs to complete and intense contraction or rigor of apparently every muscle in the body. In this latter case, the current completely supersedes the action of the mind over everything capable of contraction or movement. Consciousness, however, is apparently rarely, if ever, lost, though the subject may be entirely unable to make any motion, cry out, or do anything to help himself. If aid is not near, such a state may be maintained for some time. On release from such a position by extraneous or natural causes, the subject is usually dazed, but if at all unconscious, soon recovers completely and experiences no further functional disturbance than the debility and nervousness naturally following such a severe strain on the system." While admitting that fatal shocks are possible, this gentleman gives it as his opinion that "if the shock is not sufficient to cause instantaneous collapse, apparently the body can bear the strain of the continued passage of the current for some time, and that death is caused by paralysis of the involuntary muscles controlling the heart and lungs, and that the preliminary stages of total collapse are analogous to what occurs when drowning." Referring to the local action of the current on the body where it enters and leaves, this writer also says: "If the contact is good, that is, if it consists of a good area, say of over a couple of square inches of a fairly moist skin pressed with moderate firmness against a metallic body or other good conductor, no visible injury may result. For instance, a man will often get burnt about the hands, but his feet, by which the current leaves, will be unaffected, or only slightly reddened or inflamed. Burning of the hands or other parts of the body will occur when there is imperfect contact of the body with the conductor, coming in contact with a bad or semi-conductor, such as a dirty or carbonized surface. The burning is caused by the absolute setting up of an arc."

It seems to me this gentleman's views, based, as we are led to believe, on actual experience, are somewhat paradoxical. And surely numerous cases of deaths from currents recently, disprove many of Mr. Addenbrooke's deductions. True, nothing short of death is made public, so that there is but little information to go upon relating to the instances which must be of frequent occurrence where men are *almost* killed by electric shocks. In all cases that have come to light, whether simply injuries or cases of death, the parts of the body coming in contact with the current have been badly burned. The unfortunate "trouble hunter," who lost his life a few days since, was not only burned at the hands but at the knees. In cases where the shock is not instantly fatal, may it not be that the burning of the flesh at the points of contact is so great as to destroy to a considerable extent the conducting substance in contact with the wire, and thereby cause a fall in the current passing through the body? It is certainly owing to the fact of the body being a very poor conductor that harm is done. If it offered no resistance there would be no realization that a current was passing through it. An arc would be created at the point of contact, provided the contact was *imperfect*, but the body itself would be uninjured. It seems to me that the human body must be viewed as any other semi-conductor, with the exception perhaps of susceptibility to greater change under the continued action of a current owing to the fluids which it contains. It is owing to its resistance that a carbon filament becomes incandescent.

The carbon rod of an electric lamp is not consumed except at the point where the arc is formed by the resistance of attenuated particles under combustion. Any conducting substance placed in the path of more current than it is capable of conveying must be heated, consumed or decomposed, according to its nature and in proportion to the discrepancy between the conducting capacity of the conductor and the sum of the current.

Now if we liken the human body from hand to hand to a canvas hose or tube filled with water and which allows a certain quantity of moisture to ooze through the surface, corresponding to the moisture of the skin, and if this be inserted in a circuit, connection being made at the extreme ends, corresponding to the hands, and a shunt wire of minimum resistance be wound around the tube two or three inches from the ends, corresponding say to the wrists, we can, perhaps, more understandingly speculate on the action of a dangerous current on the human body, contact being made at the hands and the shunt wire encircling the wrists. It should be borne in mind that the contact between the shunt wire and wrists is much better than the contact at the hands, since the wrists are more tender than the hands. Now referring to the tube and assuming that the contacts at the ends have improved by reason of the current eating its way into the water, does it not follow that the current instead of following the entire length of the tube of water, offering, say 30 times the resistance of the two or three inches of water from the end of the tube to the shunt wire, and several thousand times the resistance of the shunt wire itself, will, to a great extent, pass from the tube to the shunt wire and in its passage *improve* the contact at that point as it did at the ends in entering the tube? I have often noticed that upon receiving a shock of 150 to 250 volts profuse perspiration instantly followed. This would greatly improve the contact at the wrists above the normal, so that it would seem impossible that the current should confine itself to the fluids and muscles of the body in preference to the wire when separated from the wire only by thin tender skin filled with moisture.

In considering the danger point of currents it seems reasonable to recognize the same law, or rather recognize the absence of any law, governing other destructive agencies. Let it be concussion, strain, asphyxia, poison, or other enemy of endurance, there are hardly two cases alike. One man may emerge with but slight injury from a cause which to another man would be death. Why should it not be so in the matter of electric shock? Death, of course, must be

the consequence of a certain degree of cause. If 2,000 volts are necessary to kill in any instance, one volt less would avert death, while shunting 100 or 500 volts would leave a proportionate margin of safety. Fatal results through the medium of electricity do not come by jumps any more than by any other force or element of destruction. There is in this subtle agency, as in all others, a last straw which breaks the camel's back—a last volt which does the final harm. Hence the importance of protecting, as far as possible, those exposed to this danger.

Regarding the immediate cause of death or the effect of currents on the substances of the body, we must look to the medical men for light. Probably all subjected to shock might not be similarly affected. In one case it might be the heart, in another the brain, and in others the lungs that might be injured. Why not have a thorough investigation of this subject, and then perhaps wire handlers may be subjected to an examination before they are allowed to engage in such work, just as men are examined for various other duties.

There seems to be so little known about these matters, I shall feel gratified if this paper serves as even a feeble incitement to discussion and investigation, as I can conceive of no subject offering a more humane incentive.

ON COMPENSATED RESISTANCE STANDARDS.[1]

BY EDWARD L. NICHOLS.

The electrician has few more troublesome corrections to make in the course of his measurements than those arising from the influence of temperature upon resistance. Were the heating of wires due solely to changes in the surrounding air, the matter would not be a serious one. Such changes could be reduced to a minimum by devices well known in the art of physical measurements, unavoidable changes could be determined by the aid of the thermometer, the temperature coefficient for the various elements of the circuit could be ascertained and proper corrections applied.

Since, however, heat is developed in every circuit in amount measured by the product of the current and the E. M. F. between the terminals, the temperature of a wire through which a current flows is always higher than the surrounding atmosphere. In the case of heavy currents, the temperature of the wire may be very high indeed. The difficulty of applying corrections for temperature is such as to lead to frequent rejection of methods which would otherwise be of great convenience, and might lead to results of the highest accuracy.

The discovery of a substance, the resistance of which would not change perceptibly under the influence of heat, would, it goes without saying, be of great value. Unfortunately all known metals are influenced in the same sense, nor has any alloy been found which is devoid of a temperature coefficient. The exhaustive investigations of the British Association Committee in this field are too well known to need recapitulation, and while some alloys have been recently produced which are much better than anything that committee was able to discover, even these forfeit much of their usefulness on account of their low conductivity.

One substance only, among the solid conductors of electricity, seems to offer a solution of the difficulty. Carbon, as has been shown by Matthiessen,[2] Siemens, and many later observers, differs from the metals in showing a decrease of resistance with rise of temperature. The amount of this change, which differs widely in the case of the various artificial carbons, is given in the following table :

TABLE I.

INFLUENCE OF TEMPERATURE UPON THE RESISTANCE OF VARIOUS VARIETIES OF CARBON.

Observer.	Variety of carbon.	Temperature interval.	Mean coefficient per deg.
Werner Siemens (*Wiedemann's Annalen*, 10, p. 560).	Gas carbon.........	0 to 200°	.000345
	Pressed gas carbon..	0 to 200°	.000301
Borgmann (*Journal der Russischen Physikalishen Gesellschaft*, 9 *p*. 163).	Charcoal............	26 to 260°	.00370
	Anthracite.........	20 to 250°	.00265
	Graphite.	25 to 250°	.00082
	Coke...............	26 to 245°	.00026
Kemlein (*Wiedemann's Annalen*, 12 p. 73).	Gas carbon (coarse)..	18 to 200°	.000285
	Gas carbon (fine)....	18 to 200°	.000287
	Carré's carbons.....	18 to 200°	.000321
Muroaka (*Wiedemann's Annalen* 13, p. 307)........	Paris retort carbons.	....	.000300
	Arc light carbons...	....	.000405
	Arc light carbons...	....	.000425
	Gaudoin's carbons..	....	.000415
	Kaiser and Schmidt's carbons	....	.000370
	Heilmann's carbons.	....	.000246
	Arc light carbons...	....	.000156
	Siberian graphite...	....	.000739
	Faber's lead pencil graphite..........	....	.000588

The temperature coefficient, while varying widely for different carbons, is very nearly constant for a range of more than 100 degrees, in the case of any given specimen. It seemed probable, in view of this fact, that a conductor might be constructed by combining carbon with a metal in proper proportions, in which the influence of temperature upon the carbon and the metal respectively would precisely counterbalance each other, thus securing to the combination a constant resistance throughout a considerable range of temperature.

The calculation of the proportions necessary to this result, in the case of carbon, the coefficient of which has been determined, and a given metal, copper for example, is very simple.

Assuming that the combination would be subject to the law of parallel circuits, no alloy being formed, and no chemical combination between the parts taking place, we have for the total resistance R:

$$R = \frac{R_m R_c}{R_m + R_c},$$

where R_m is the resistance of the metal and R_c the resistance of the carbon.

The equation of condition, for complete compensation will be

$$\frac{R_m' R_c'}{R_m' + R_c'} = \frac{R_m'' R_c''}{R_m'' + R_c''}$$

where R_m' R_c' are the resistances of the components and R_m'' R_c'', the corresponding resistances at any other temperature within the limits of temperature for which compensation exists.

Now the variation of the resistance of a metal with the temperature may be expressed by an equation of the form :

$$R_m'' = R_m' (1 + at \pm bt^2),$$

where a and b are coefficients to be determined by experiment.

In the case of carbon, the coefficient a will have a negative value, and the equation will take the following form :

$$R_c'' = R_c' (1 - at \pm bt^2).$$

Between 0° and 100° the value of b in the case both of

1. Read before the American Institute of Electrical Engineers, May 16, 1888
2. Matthiessen, *Poggendorff's Annalen*, 115, p. 353.

copper and carbon is very small. A recent determination of the coefficients for copper, made in the Physical Laboratory of Cornell University, yielded the equation :

$$R_m'' = R_m' (1 + .00380\, t + .00000047\, t^2).$$

The experiments, which covered a range of 100°, are in close agreement with the results published by Matthiessen.

In the above equation, for $t = 100°$, we have $bt^2 = .0047$. If we neglect the coefficient b and adopt for a the mean coefficient between 0° and 100°, we may write the equation in the simpler form,

$$R_m'' = R_m' (1 + .003847\, t),$$

which will give results agreeing with the complete form at 0° and 100°, and will have a maximum error, at 50°, of .0008.

In the case of carbon the coefficient b may also be neglected without appreciable error.

A Carré pencil, measured by another member of the same laboratory, gave as mean coefficient between 0° and 100°, the value .000235.

We may, therefore, write the equation for this variety of carbon, as follows :

$$R_c'' = R_c' (1 - .000235\, t).$$

The relative influence of heat upon the resistance of copper and carbon is shown graphically in figure 1, which

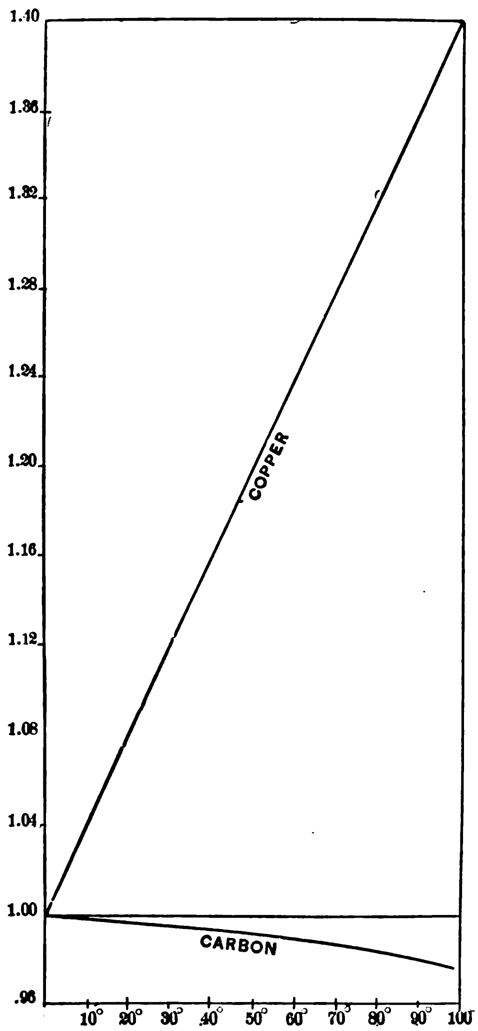


Fig. 1.

diagram will also serve to indicate the nearly constant value of the temperature coefficient of those substances.

In combining copper and carbon in such proportions that the resulting resistance shall be independent of the temperature, the following equation of condition must be satisfied.

$$\frac{R_m'\, R_c'}{R_m' + R_c'} = \frac{R_m''\, R_c''}{R_m'' + R_c''}.$$

This equation will be satisfied only for a range of temperatures throughout, which $b^2\, t$ is negligible, in the case of both substances.

For such a range of temperatures we have, however, as already indicated,

$$R_m'' = R_m' (1 + a_m\, t)$$
$$R_c'' = R_c' (1 - a_c\, t);$$

where a_c and a_m are the coefficients for carbon and copper respectively.

Within such limits

$$\frac{R_m'\, R_c'}{R_m' + R_c'} = \frac{R_m' (1 + a_m\, t)\, R_c' (1 - a_c t)}{R_m' (1 + a_m\, t) + R_c' (1 - a_c\, t)};$$

which is readily reducible to the form,

$$R_m' \left(\frac{a_c\, t}{1 - a_c\, t} \right) = R_c' \left(\frac{a_m\, t}{1 + a_m\, t} \right)$$

Using the coefficients already determined for copper and the variety of carbon in question, namely :

$$a_m = .003847.$$
$$a_c = .000235.$$

We find,

$$R_m = 11.544\, R_c.$$

In a word, we must use, for every ohm of carbon, 11.544 ohms of copper in order to secure complete compensation for temperature.

Three methods of combining the copper and carbon in such a compensated resistance have occurred to me as likely to give a good result. The first method consists in wrapping an insulated wire, of the necessary resistance, around the carbon and soldering the ends to the terminals of the bar, previously copper-plated for that purpose. The second method consists in mixing the proper amount of copper in a finely divided state with the paste of which the rod is to be made, and then molding and baking the carbon in the usual manner.

In the third method, which is the only one which I have as yet put to actual trial, the carbon, having been tested and its temperature coefficient determined, is electro-plated with copper. Experience showed that the film of copper necessary to compensation was so thin as to be scarcely adherent. The following process was therefore submitted for that of coating the entire surface. A Carré carbon 2.95 mm. in diameter was copper-plated for about 5 mm. at each end. The ends were then amalgamated and placed in mercury cups, which formed the terminals of a Wheatstone bridge. The resistance of the rod having been measured, and its mean coefficient between 20° and 100° having been determined, the length necessary for a compensated resistance of one legal ohm was calculated. The rod was then cut to the proper length, allowing 5 mm. at each end for terminals. The ends were heavily plated, and were inserted into the ends of copper rods, which were carefully soldered to the carbon. The rod was then given a coat of shellac, and, when dry, a strip of the varnish was removed with a sharp knife. The strip laid bare was parallel to the axis of the rod, and extended from terminal to terminal. Its width was about 1 mm. The rod was then submerged in a plating bath of sulphate of copper.

In this way a film of copper was deposited upon the exposed portion, which combined the required electrical resistance, 11.544 ohms, with sufficient thickness to render it tough and adherent. It was found that one gravity cell, acting through 50 ohms, would deposit the requisite amount of copper for a one ohm bar, in about 10 minutes. When the above process had been carefully carried out, the rod was found to have very nearly the proper total resistance and to be nearly perfect in the matter of compensation. If the rod was over-compensated, copper was removed by careful scraping. If it was under-compensated, carbon was

removed by the same process. These final adjustments were continued until the rod showed no perceptible change of resistance when heated to 100°. When the compensation was regarded as satisfactory, the adjustment of total resistance was made by removing the copper-plating of the terminals, or extending the same by renewed plating. This, if carefully done, would bring the rod to the proper resistance without impairing the compensation. The rod, after adjustment, was well varnished, and was inserted in a glass tube of about 7 mm. internal diameter. This tube was provided with brass caps, through which the copper terminals projected to a distance of about 5 cm. These, after being securely riveted to the brass caps, were bent through an angle of 90°. When thus mounted the resistance-rod presented the appearance indicated in figure 2.

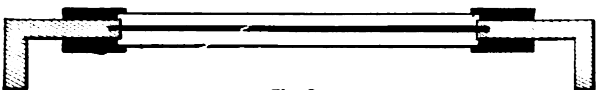


Fig. 2.

In the manner just described, I succeeded after a few trials in producing a resistance rod upon which the influence of the temperature between 18° and 100° was entirely imperceptible. The object being to test the method of compensation, and not to produce a standard ohm, the adjustment for final resistance was not carried out.

The resistance of the compensated rod, after being mounted, is shown in the following table :

TABLE II.

RESISTANCE OF A COMPENSATED RESISTANCE ROD AT VARIOUS TEMPERATURES ; MEASUREMENTS BY MR. GEO. D. SHEPARDSON.

Temperatures.	Resistance in B. A. ohms.
105° C.	1.0300
98°	1.0300
87°	1.0305
35°	1.0305
22.5°	1.0295
19°	1.0300

For the purpose of this measurement, the rod was immersed in an oil bath and heated to more than 100°. The readings were taken while the bath was cooling. They indicate a practically perfect compensation throughout the range of temperature given in the table.

If such a compensated resistance-rod be quickly heated or cooled, the copper will change more promptly than the carbon and the balance will be temporarily destroyed. While in process of heating from without, the resistance will increase somewhat, and while cooling by radiation the reversed effect will be noticeable.

In rods not mounted in glass and unprotected by a coating of varnish these variations are very marked. Table iii. contains a set of readings made upon such a rod. The rod was rapidly heated and cooled, and was measured several times during the rise and fall of temperature. The compensation was nearly complete, the mean coefficient between 20° and 100 being less than .00002, but the rod in question exhibited temporary variations when suddenly heated and cooled, amounting to more than one per cent.

TABLE III.

TEMPORARY VARIATIONS OF A COMPENSATED ROD SUBJECTED TO SUDDEN CHANGES OF TEMPERATURE.

Temp.	Resistance.	Temp.	Resistance.
25°	1.0050	78°	1.0030
(Gas ignited.)		(Gas extinguished.)	
37°	1.0072	78°	0.9965
45°	1.0074	74°	0.9960
55°	1.0070	63°	0 9975
62°	1.0040	40°	1.0030
68°	1.0040	25°	1.0050
70°	1.0040		

Compensated resistance-bars, such as have been described in this paper, are of course limited in their application to uses in which carbon conductors are admissible. For standards of resistance I think they will be found especially valuable. The convenience of having a comparison resistance the value of which can be determined once for all, and which can then be used with confidence, without regard to its temperature, even in circuits which would heat our ordinary standard coils and modify their resistances to a notable extent, will be appreciated by all. In the construction of low-resistance shunts, also, the possibility of obtaining a conductor which will remain unchanged at all ordinary temperatures, whether heated from without or by the passage of the current, will permit us to adopt with confidence the use of high resistance galvanometers, with low resistance shunts, for the measurement of large currents, even where the highest accuracy is necessary.

To those who, in the course of their electrical work, have to cope daily with the question of the influence of temperature upon resistance, numerous other applications of compensated resistance-rods will suggest themselves.

THE POSSIBILITIES AND LIMITATIONS OF CHEMICAL GENERATORS OF ELECTRICITY.[1]

BY FRANCIS B. CROCKER.

ELECTRO-CHEMISTRY seems less generally and less clearly understood than any other branch of electricity of equal importance. The facts concerning the dynamo, motor, telegraph and telephone are widely and definitely known ; but there are ideas, statements and claims in regard to batteries which are further from the truth, more prevalent and go longer without being contradicted than any other collection of errors that I can call to mind.

Primary batteries have not received the attention in this country that they have abroad, particularly in England, where the successful or unsuccessful attempts to float a new primary battery company is a matter of almost weekly occurrence. Nevertheless the subject is a sufficiently important one, and the false ideas of which I have spoken have spread so far beyond the quacks, to whom such ideas are usually confined, that the subject deserves more study than it usually receives, particularly from the scientific standpoint.

Electromotive force.—The electromotive force which a given battery or combination of materials will develop is the first and most important question in electro-chemistry. Of course, the best and surest way to arrive at this E. M. F. is to determine it by actual experiment with a voltmeter, or, still better, by comparison with a standard cell. There are, however, many times when the materials or instruments are not at hand, and a calculation or predetermination of the E. M. F. is very convenient.

The formula for calculating the E. M. F. is obtained by assuming that the electrical energy of the given chemical combination is equal to the heat energy which the same combination is capable of producing, or $E\ C = 4.16\ C\,a\,H$, that is, volts multiplied by coulombs is equal to the coulombs multiplied by the electro-chemical equivalent, *i. e.*, the weight of material required per coulomb and that by the heat produced by one gramme of the material. The electrical equivalent of heat 4.16 is introduced to reduce both members of the equation to an electrical basis. Canceling the C in both members, we have $E = 4.16\ aH$, in which E is the E. M. F. in volts, a is the electro-chemical equivalent (grammes per coulomb), and H is the number of heat units (gramme-degrees Cent.) produced per gramme of material by the given chemical combination. The values of a and H are given for most materials in electrical and chemical books of reference, and the calculation is a very simple one; nevertheless this formula and the principle involved in it are not generally understood, and are very seldom used. The equation deduced above is that ordinarily given, but what I have found to be a more convenient form of it is obtained by assuming that $E = I$, giving a its

1. Read before the American Institute of Electrical Engineers, May 16, 1888.

value for hydrogen (.00001035). Solving with respect to H we have $H = 23300$, which means that 23300 is the number of heat units per equivalent corresponding to one volt, and all that is necessary to find the volts of any given chemical combination is to divide the number of heat units per equivalent (which is the form they are almost always given in) by 23300 and the quotient is the E. M. F. in volts. For example, to obtain the E. M. F. which zinc and free chlorine will develop, divide 48600 (which is the number of heat units produced by the combination of one equivalent of zinc with one of chlorine as given by Thomsen) by 23300, and the result 2.09 is certainly very close to 2.11, the actual value obtained by experiment. In the same way the E. M. F. of other combinations of materials may be predetermined, but it should always be borne in mind that the heat of combination corresponding to one *equivalent* of the material should be taken and not necessarily that corresponding to one atom; as for example in the case of zinc, the heat per atom (65 grammes) is 97,200 which has to be divided by 2 to reduce it to one equivalent that. There has been no warping or coaxing of the figures to secure uniformity. The results are given just as they came. If figures were picked out from the different observations, it would be possible to obtain almost perfect agreement between the calculated and determined, as one may see by looking over the tables.

In regard to the experimental results as given in tables A, B and C, I may state that all the metals and salts used were chemically pure, with the exception of the metals magnesium and aluminium, and these were of a very good quality. Pure carbon plates were used for the negative plate, but platinum was also tried and gave substantially the same results. The E. M. F. was measured by a Thompson reflecting galvanometer (by Elliott), using two independent standard Daniell cells. One fact which strikes one in looking over the tables A, B and C, is that the E. M. F. is not very greatly affected by the solution; a certain metal gives about the same result in one chloride as in another, and the same is true of the bromides and iodides. In table E, I have given the E. M. F. obtained by substituting different metals for the zinc in a Daniell's cell, but these results being from only one series of observations are probably not so reliable as those in the preceding tables.

SYMBOLS. — Chemical expressions reduced to a common basis.	CHEMICAL EQUIVALENTS. — Proportions in which materials combine.	ELECTRO-CHEMICAL EQUIVALENT. — Weight of material consumed per amp. sec.	NAME OF MATERIALS.	Electro-motive Force produced.	Weight of zinc consumed per Horse Power hour.	Weight of Depolarizer consumed per Horse Power hour.	Weight of Materials consumed per amp hour in each cell.	Cost of Materials wholesale.	Total Cost of both positive and negative materials per Horse Power hour.
	H=1.	milligrams per coulomb.		Volts.	Pounds.	Pounds.	Pounds.	Per Pound.	
$\frac{1}{2}$ Zn	32.5	.337	Metallic Zinc, ...				.0027	$.07	
+			used with following electronegative or depolarizing elements:						
I	127.	1.314	Free Iodine.............	1.2	1.67	6.53	.0105	3.50	$22.97
Br	80.	.828	Free Bromine............	1.79	1.12	2.76	.0066	.38	1.12
Cl	35.5	.367	Free Chlorine	2.11	.95	1.04	.0029		
$\frac{1}{2}$ O	8.	.083	Free Oxygen*............	1.9	1.05	.26	.00066		
$\frac{1}{2}$ S	16.	.166	Free Sulphur*...........	.95	2.1	1.03	.0013	.02	.17
			CHEMICAL COMPOUNDS.						
$\frac{1}{2}$ H_2O	9.	.093	Water *................	.5	4.	1.1	.00074		
HNO_3	63.	.652	Nitric Acid.............	1.9	1.05	2.04	.0052	.06	.20
$\frac{1}{3}$ CrO_3	33.4	.346	Chromic Acid............	2.	1.	1.03	.0027	.20	.28
$\frac{1}{2}$ $CuSO_4$	79.7	.826	Copper Sulphate (anhyd.).	1.079	1.86	4.55	.0065		
$\frac{1}{2}$ $CuSO_4 \cdot 5H_2O$	124.7	1.29	Copper Sulphate Crystals,	1.079	1.86	7.13	.0102	.06	.56
$\frac{1}{6}$ Fe_2Cl_6	162.5	1.683	Iron Perchloride.........	1.55	1.3	6.5	.0133	.10	.74
AgCl	143.5	1.487	Silver Chloride..........	1.06	1.89	8.32	.0118	16.00	133.25
$\frac{1}{2}$ Hg_2SO_4	248.	2.57	Mercury Sulphate........	1.42	1.41	10.7	.0204	.50	5.45
			MIXTURES.					Mixture per lb.	
$\frac{1}{6}$ { $K_2Cr_2O_7$ / $7H_2SO_4$ }	163.5	1.694	{ Potass. bichrom, 3 pts. / Sulphuric acid, 7 parts }	2.	1.	5.03	.0133	.04	.27
$\frac{1}{3}$ { $K_2Cr_2O_7$ / $4H_2SO_4$ }	229.	2.37	{ Potass bichrom., 3 pts / Sulphuric acid, 4 parts }	2.	1.	7.04	.0186	.05	.42

* Calculated.

because zinc is a dyad and takes two atoms of chlorine, which is a monad. In the case of monad metals, like sodium, potassium and silver, the figures may be taken just as they are given in the tables. Mistakes very frequently arise in this way; in fact I do not think I ever saw a table of electro chemical equivalents in which this point was correctly introduced in every case.

In order to test the practicability and accuracy of calculating E. M. F. as well as to obtain reliable results and full data for their own value, I determined the E. M. F. given by thirteen of the most important metals in combination with free chlorine, bromide and iodine, and the results are given in tables A, B and C respectively. In table D I have averaged these results and placed them side by side with the results obtained by calculation. The agreement between the two sets of figures is not perfect by any means, but when it is remembered how the E. M. F. of a cell will change one or two-tenths of a volt on apparently the slightest provocation, I think the figures are strikingly close, more so than I expected to find them. In more than half of the cases the difference is less than one-tenth of a volt, and the average difference is only slightly more than

In the remaining table I have collected in condensed form the principle facts in regard to batteries in which zinc is used as the electro-positive material with the most important electro-negative or depolarizing materials. The facts in regard to metallic zinc, which hold good in all cases in which it is used (no matter what the other material is), are given on a horizontal line with zinc. Below this the facts in regard to each particular combination are given opposite the depolarizer. For example, the data of a zinc and chlorine battery are given on a horizontal line with chlorine, of a zinc and nitric acid (Bunsen) battery on a line with nitric acid.

For convenience the table is divided into two parts; the left-hand side contains the purely scientific data, and the right-hand portion contains the practical facts.

In the first column of the first part is given the chemical symbols reduced to a common basis, any one of the expressions being chemically equivalent to any other. For example, one-half atom of zinc ($\frac{1}{2}$Zn) requires one atom of

chlorine (Cl), or one-half atom of oxygen ($\frac{1}{2}O$), or one-third molecule of chromic acid ($\frac{1}{3}Cr_2O_3$), or one-sixth of the mixture of one molecule of potassium bichromate and seven molecules of sulphuric acid ($\frac{1}{6}[K_2Cr_2O_7 + 7H_2SO_4]$), and so on.

In the second column is given the chemical equivalents which are simply the proportions by weight required of the different materials. That is, when we use 32.5 grammes of zinc (hydrogen being assumed as one gramme), we require 35.5 grammes of chlorine, or 33.4 grammes of chromic acid, and so on.

The third column contains the electro-chemical equivalents, which are really exactly the same and directly proportional to the combining weights in the previous column, parts of sulphuric acid, which is about the ordinary strong bichromate solution for porous cell batteries. Of course the water required for the solution is not considered here or in any of the other figures of the tables, because it costs nothing and serves merely as a medium of electrical action; but if the total weight of solution is desired, the weight of water must be added.

The weight of the different materials consumed per ampere hour is given in the next column. These figures are obtained directly from the electro-chemical equivalents in the third column by dividing by 125; in fact, they are simply the electro-chemical equivalents in pounds per ampere hour.

It should always be carefully noted that the weight

TABLE A.

E. M. F. produced by different Metals in Combinations with Free Chlorine in Solutions of —.

	Magnesium Chloride.		Zinc Chloride.	Zinc Chloride.	Zinc Chloride.	Hydro-Chloric Acid.	Common. Salt.	Average.
Magnesium	2.83	2.65	2.65			3.2–3.15	2.85	3.1
Zinc	2		2.20	2.13	2.11	2.20	2.18	2.11
Cadmium			1.94		1.86	1.98	1.93	1.9
Aluminium	1.75		2.04	1.88		2.02	1.98	2.
Iron			1.60	1.56	1.5	1.67	1.68	1.6
Cobalt			1.43	1.43	1.41	1.50	1.45	1.43
Nickel			1.33		1.27	1.40	1.33	1.33
Tin	1.50		1.70	1.6	1.57	1.68	1.66	1.61
Lead			1.63	1.62	1.60	1 68	1.65	1.63
Copper			1.31	1.30	1.29	1.37	1.34	1.32
Silver			1.11	1.12	1.13	1.15	1.10	1.11
Antimony			1.20	1.23	1.25	1.25	1.08	1.22
Bismuth			1.29	1.25	1.20	1.27	1.19	1.21

but are reduced to an electric basis of so many milligrammes per coulomb. To convert these figures into grammes per ampere hour simply multiply by 3.6.

In the first column of the second part of the table is given the E. M. F. of each combination, all of which with the exception of oxygen, sulphur and water are determined by experiment, most of them being well known and accepted values. In the case of oxygen, sulphur and water the E. M. F. is calculated as explained above and is consumed per ampere hour is that required in *each cell* in *series*, whereas in the case of horse-power hours the weight given in the table is the total weight used, no matter how many cells there are or how they are arranged.

In the next to the last column is given the wholesale cost per pound of the different materials. These prices are of course very difficult to fix, because they depend upon the market and vary greatly upon the quantities bought; but the prices I have here are very low, and ordinary con-

TABLE B.

E. M. F. of different Metals with Free Bromine in solutions of

	Magnes. Bromide.	Nickel Bromide.	Potass. Bromide.	Hydro-Bromic. Acid.	Magnes. Br'mide weak.	Average
Magnesium	2.55	2.45	2.51	2.7	2.57	2.56
Zinc	1.84	1.78	1.82	1.79	1.85	1.79
Cadmium	1.6	1.54	1.62	1.57	1.61	1.58
Aluminium	1.5	1.46	1.47	1.46	1.6	1.53
Iron	1.22	1.25	1.31	1.26	1.33	1.3
Cobalt	1.1	1.02	1.05	1.06	1.13	1.05
Nickel	.8	.85–.8	.8	.87	.94	.85
Tin	1.12	1.31	1.3	1.25	1.27	1.3
Lead	1.4	1.27	1.33	1.28		1.33
Copper	1.05	.96	1.01	.99	1.03	1.02
Silver	.97	.94	.97	.95	.93	.95
Antimony	.99	.73	.71	.87	.97	.8
Bismuth	.92	.9	.96	.88	.92	.92

merely given for comparison. No actual battery corresponding to these materials exists.

In the second column, on the right-hand side, is given the number of pounds of zinc required per horse-power hour in the case of each combination. For example, a zinc and copper sulphate (Daniell) battery requires 1.86 pounds of zinc per horse-power hour of electrical energy produced.

In the next column I give the weight of depolarizer required per horse-power hour in the case of each combination. For example, a battery requires 5.05 pounds of the mixture of three parts of potassium bichromate; and seven sumers would have to pay twice as much in most cases; they give, however, some idea of costs.

In the last column I have given the cost of both materials, zinc and depolarizer, added together. I have not here considered the values of the products, because it is very difficult to estimate the cost of collecting and utilizing residues. In the case of silver chloride the silver resulting from the action would, of course, be worth a large portion of the cost of the original chloride.

One of the interesting points which this table shows is the total weight required per horse-power hour. For example, .95 pound of zinc and 1.04 pounds of chlorine,

making a total of almost exactly two pounds, would produce one horse-power of current for one hour if all of the chemical energy could be converted into electric energy.

This brings up the question of how large a percentage of the chemical energy can be utilized, or, in other words, the efficiency of chemical generators. This efficiency is higher, I think, than it is generally supposed to be. I have no exact figures upon this point, but I have tested several times the weight of zinc consumed compared with the theoretical amount, and I have found that even in a plunge battery, where the bichromate solution was directly in contact with the zinc and the opportunity for local action was a maximum, that the zinc efficiency was as high as 75 per cent., and in one case 80 per cent. In a porous cell battery with amalgamated zinc, where there was little or no cause for local action, I believe the zinc efficiency would be as high as 90 per cent., and I should not be surprised to find it as high as 96 or 97 per cent.

The efficiency of the depolarizer is generally lower than that of the zinc, because there is generally a good deal of chemical energy left in the solution after it is too weak for satisfactory work. The efficiency of the bichromate solution in the plunge battery I have just referred to was only about 45 per cent. of the total theoretical power. But this is very low, because the solution has to be weak in acid on account of being used in contact with the zinc. In the case of a copper sulphate battery, where the crystals of sulphate are often almost entirely used up, I think the efficiency would be as high as 80 or 90 per cent. The efficiency I speak of here is simply the *chemical* efficiency in the battery; the fall of potential in the battery due to its internal resistance compared to the external is another loss which has to be added to the chemical loss in determining the total efficiency.

The possibilities of chemical generators are, therefore, almost infinite, since it requires theoretically a total of only two pounds of zinc and chlorine, and two pounds of zinc and chromic acid per horse-power hour, and since the efficiency of batteries can easily be made as high as 75 per cent. it follows that less than three pounds of material is actually required per horse-power hour; but unfortunately the water for the solution, the containing vessel, electrodes, etc., are so heavy that the total weight is very many times greater. The possible and the actual battery are thus very far apart. If we use metals of higher chemical affinity and E. M. F. than zinc the theoretical weight of material required is even less; only one pound total of chlorine and magnesium are required per horse-power hour; with metallic sodium and free chlorine having a calculated E. M. F. of 4 volts it would only take about .8 pound per horse-power.

TABLE C.

E. M. F. of different Metals with free Iodine in solutions of —,

	Magnes. Iodide.	Zinc Iodide.	Potass. Iodide.	Average
Magnesium	2.02		2.00	2.01
Zinc	1.35	1.23	1.29	1.25
Cadmium	1.12	1.12	1.13	1.12
Aluminium	.92	.83	.87	.88
Iron	.69	.6	.74	.68
Cobalt	.6	.42	.5	.51
Nickel		.35	.37	.36
Tin		.72	.69	.71
Lead		.82	.85	.83
Copper	.63	.67	.62	.64
Silver	.65	.67	.64	.65
Antimony	.41	.47	.46	.44
Bismuth	.39	.46	.42	.43

TABLE D.

Comparison of the E. M. F. Calculated from the Heat of Combination and the E. M. F. determined by experiment.

Metals.	Combining with Chl'rine Calc.	Determ.	Bromine Calc.	Determ.	Iodine Calc.	Determ.
Magnesium	3.24	3.1				
Zinc	2.09	2.11	1.68	1.79	1.05	1.25
Cadmium	2.	1.9	1.58	1.58	.97	1.12
Aluminium	2.3	2.	1.7	1.53	1.00	.88
Iron	1.75	1.6	1.5	1.3	.85	.68
Cobalt	1.64	1.43				
Nickel	1.57	1.33				
Tin	1.71	1.61	1.5	1.3		
Lead	1.76	1.63	1.38	1.33	.85	.83
Copper	1.4	1.32	1.07	1.02	.69	.64
Silver	1.25	1.11	.97	.95	.59	.65
Antimony	1.3	1.22				
Bismuth	1.3	1.21				

TABLE E.

E. M. F. produced by different Metals substituted for the Zinc in a Daniels cell.

Metals.	Volts.	Metals.	Volts.
Zinc	1.08	Lead	.58
Cadmium	.79	Copper	.07
Aluminium	.65	Silver	—.03
Iron	.64	Antimony	.09
Cobalt	.40	Bismuth	.17
Nickel	.1		

The easiest and best solution of the problem, however, does not seem to be the use of more powerful metals than zinc. The latter is powerful enough; it only takes, as we have seen, about one pound of it per horse-power hour with nitric acid, chromic acid or bichromate solution, and less than two pounds with copper sulphate. The opportunity for improvement seems to lie more in the direction of perfecting the general form of batteries. The *apparatus* is at fault, not the *chemical action*. Moreover, zinc is about as high on the electro-positive scale as it is safe to go so long as water is present. Even in the case of zinc its affinity for oxygen is greater than that of hydrogen; it is therefore only by tolerance, so to speak, that zinc remains passive in the presence of water. If it is not properly amalgamated, or if the solution is too strong, local action does occur. If, in place of zinc, we use any more electro-positive metal these troubles are aggravated; with magnesium, for example, there are only very few solutions in which it will stand without great local action. Metals of still higher power, such as sodium, cannot be used at all in presence of water. Jablochkoff has, I believe, made cells in which sodium is used with damp cloth, but this can hardly be considered as water.

The proper way to use metals of great chemical energy would seem to be with liquids which do not contain any oxygen, but unfortunately such solutions are not generally good conductors. Another possible plan is to employ a fused electrolyte, but this involves the serious difficulty of maintaining it in the fused state.

So far as I can see, zinc is a very satisfactory positive material for batteries. After all it is cheaper than any other metal except iron. It is a sufficiently good conductor, and less dirty and liable to corrosion than almost any other metal; it is also, as I have just shown, about as high on the electro-positive list as it is safe to go.

The electro-negative materials on the other hand leave far more to be desired. They are generally expensive, very troublesome to handle, and introduce that quality of simple dirtiness, to which no other name can be applied, and which is really the most serious objection to batteries. The electro-negatives will, however, do the work, and as we have seen it actually requires very little weight to give a great deal of power, if the materials could only be used in a more perfect manner than at present. That seems to be the thing to hope for. Another serious difficulty with batteries is their high internal resistance. A dynamo can easily be made to give 100 volts with a thousandth or a few ten thousandths of an ohm internal resistance, hence their great output; but a primary battery capable of giving 100 volts with only one thousand ohm internal resistance would probably fill this house.

In this connection it will be interesting to consider how many cells of ordinary gravity battery are required to give one horse-power of current. Each cell will give one volt and not more than half an ampere under normal conditions, hence each cell furnishes half a watt or about 1,500 cells to the horse-power. These cells would, however, give that power for a long time. But the fact remains that this very large number is required to produce the power which a dynamo not much larger than one's hat will generate.

In conclusion, I would say that I am by no means a skeptic in regard to chemical generators of electricity; the possibilities are very, very great, as I have shown. But these possibilities do not seem to have been brought to reality in a very perfect manner as yet. But batteries, even in the imperfect state in which they exist to-day, have their useful and legitimate function. A Leclanché cell is exceedingly well adapted to ringing electric bells intermittently and to telephone work, and gravity batteries have long done good service for telegraphic purposes.

But when it comes to developing any considerable amount of actual power, then the limitations become apparent. When we remember that battery electricity will certainly cost in practice 50 cents per horse-power hour, since the materials alone cost 25 cents, and that dynamo electricity only costs 2 cents per horse-power hour, the claims of some primary battery electric lighting promoters show up in their true light. As a luxury, of course, it makes very little difference what it costs, but even then people soon tire of paying very high prices for that kind of a luxury. For small electric lighting and small power in special cases batteries are useful, particularly where no other source of current is available. A physician or dentist to whom a horse-power hour may be worth hundreds of dollars could almost afford to use a chloride of silver battery and throw away the silver.

A NEW SYSTEM OF ALTERNATE CURRENT MOTORS AND TRANSFORMERS.[1]

BY NIKOLA TESLA.

In the presence of the existing diversity of opinion regarding the relative merits of the alternate and continuous current systems, great importance is attached to the question whether alternate currents can be successfully utilized in the operation of motors. The transformers, with their numerous advantages, have afforded us a relatively perfect system of distribution, and although, as in all branches of the art, many improvements are desirable, comparatively little remains to be done in this direction. The transmission of power, on the contrary, has been almost entirely confined to the use of continuous currents, and notwithstanding that many efforts have been made to utilize alternate currents for this purpose, they have, up to the present, at least as far as known, failed to give the result desired. Of the various motors adapted to be used on alternate current circuits the following have been mentioned: 1. A series motor with subdivided field. 2. An alternate current generator having its field excited by continuous currents. 3. Elihu Thomson's motor. 4. A combined alternate and continuous current motor. Two more motors of this kind have suggested themselves to me. 1. A motor with one of its circuits in series with a transformer and the other in the secondary of the transformer. 2. A motor having its armature circuit connected to the generator and the field coils closed upon themselves. These, however, I mention only incidentally.

The subject which I now have the pleasure of bringing to your notice is a novel system of electric distribution and transmission of power by means of alternate currents, affording peculiar advantages, particularly in the way of motors, which I am confident will at once establish the superior adaptability of these currents to the transmission of power and will show that many results heretofore unattainable can be reached by their use; results which are very much desired in the practical operation of such systems and which cannot be accomplished by means of continuous currents.

Before going into a detailed description of this system, I think it necessary to make a few remarks with reference to certain conditions existing in continuous current generators and motors, which, although generally known, are frequently disregarded.

In our dynamo machines, it is well known, we generate alternate currents which we direct by means of a commutator, a complicated device and, it may be justly said, the source of most of the troubles experienced in the operation of the machines. Now, the currents so directed cannot be utilized in the motor, but they must—again by means of a similar unreliable device—be reconverted into their original state of alternate currents. The function of the commutator is entirely external, and in no way does it affect the internal working of the machines. In reality, therefore, all machines are alternate current machines, the

1. Read before the American Institute of Electrical Engineers, May 16, 1888.

currents appearing as continuous only in the external circuit during their transit from generator to motor. In view simply of this fact, alternate currents would commend themselves as a more direct application of electrical energy, and the employment of continuous currents would only be justified if we had dynamos which would primarily generate, and motors which would be directly actuated by such currents.

But the operation of the commutator on a motor is twofold; firstly, it reverses the currents through the motor, and secondly, it effects, automatically, a progressive shifting of the poles of one of its magnetic constituents. Assuming, therefore, that both of the useless operations in the system, that is to say, the directing of the alternate currents on the generator and reversing the direct currents on the motor, be eliminated, it would still be necessary, in order to cause a rotation of the motor, to produce a progressive shifting of the poles of one of its elements, and

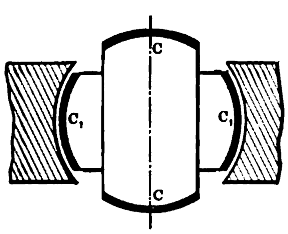


Fig. 1.

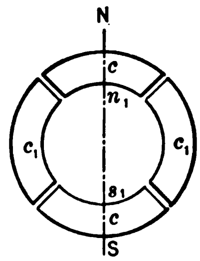


Fig. 1a.

the question presented itself,—How to perform this operation by the direct action of alternate currents? I will now proceed to show how this result was accomplished.

In the first experiment a drum-armature was provided with two coils at right angles to each other, and the ends of these coils were connected to two pairs of insulated contact-rings as usual. A ring was then made of thin insulated plates of sheet-iron and wound with four coils, each two opposite coils being connected together so as to produce free poles on diametrically opposite sides of the ring. The remaining free ends of the coils were then connected to the contact-rings of the generator armature so as to form two independent circuits, as indicated in figure 9.

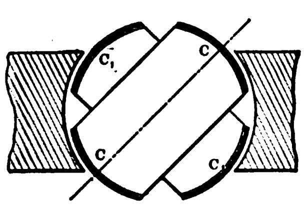


Fig. 2.

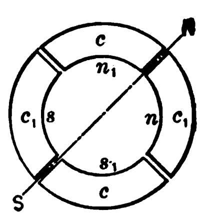


Fig. 2a.

It may now be seen what results were secured in this combination, and with this view I would refer to the diagrams, figures 1 to 8*a*. The field of the generator being independently excited, the rotation of the armature sets up currents in the coils C C, varying in strength and direction in the well-known manner. In the position shown in figure 1 the current in coil C is nil while coil C_1 is traversed by its maximum current, and the connections may be such that the ring is magnetized by the coils c_1 c_1 as indicated by the letters N S in figure 1*a*, the magnetizing effect of the coils *c c* being nil, since these coils are included in the circuit of coil C.

In figure 2 the armature coils are shown in a more advanced position, one-eighth of one revolution being completed. Figure 2*a* illustrates the corresponding magnetic condition of the ring. At this moment the coil C_1 generates a current of the same direction as previously, but weaker, producing the poles n_1 s_1 upon the ring; the coil C also generates a current of the same direction, and the connections may be such that the coils *c c* produce the poles *n s*, as shown in figure 2*a*. The resulting polarity is indicated by the letters N S, and it will be observed that the poles of the ring have been shifted one-eighth of the periphery of the same.

In figure 3 the armature has completed one-quarter of

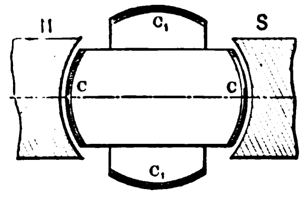


Fig. 3.

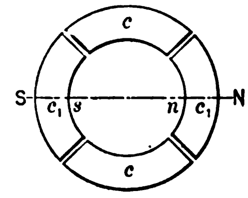


Fig. 3a.

one revolution. In this phase the current in coil C is maximum, and of such direction as to produce the poles N S in figure 3*a*, whereas the current in coil C_1 is nil, this coil being at its neutral position. The poles N S in figure 3*a* are thus shifted one-quarter of the circumference of the ring.

Figure 4 shows the coils C C in a still more advanced position, the armature having completed three-eighths of one revolution. At that moment the coil C still generates a current of the same direction as before, but of less strength, producing the comparatively weaker poles *n s* in figure 4*a*. The current in the coil C_1 is of the same strength, but of opposite direction. Its effect is, therefore, to produce upon the ring the poles n_1 and s_1 as indicated, and a polarity, N

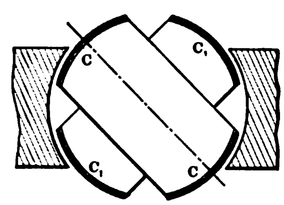


Fig. 4.

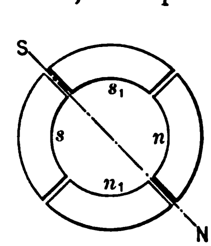


Fig. 4 a.

S, results, the poles now being shifted three-eighths of the periphery of the ring.

In figure 5 one-half of one revolution of the armature is completed, and the resulting magnetic condition of the ring is indicated in figure 5*a*. Now, the current in coil C is nil, while the coil C_1 yields its maximum current, which is of the same direction as previously; the magnetizing effect is, therefore, due to the coils c_1 c_1 alone, and, referring to figure 5*a*, it will be observed that the poles N S are shifted one-half of the circumference of the ring. During the next half revolution the operations are repeated, as represented in the figures 6 to 8*a*.

A reference to the diagrams will make it clear that during one revolution of the armature the poles of the ring

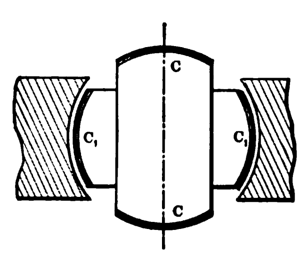


Fig. 5.

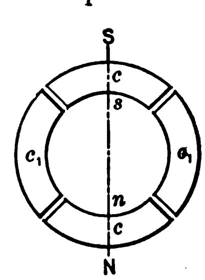


Fig. 5 a.

are shifted once around its periphery, and each revolution producing like effects, a rapid whirling of the poles in harmony with the rotation of the armature is the result. If the connections of either one of the circuits in the ring are reversed, the shifting of the poles is made to progress in the opposite direction, but the operation is identically

the same. Instead of using four wires, with like result, three wires may be used, one forming a common return for both circuits.

This rotation or whirling of the poles manifests itself in a series of curious phenomena. If a delicately pivoted disc of steel or other magnetic metal is approached to the ring it is set in rapid rotation, the direction of rotation varying with the position of the disc. For instance, noting the direction outside of the ring it will be found that inside the ring it turns in an opposite direction, while it is unaffected if placed in a position symmetrical to the ring. This is easily explained. Each time that a pole approaches it induces an opposite pole in the nearest point on the disc, and an attraction is produced upon that point; owing to this, as the pole is shifted further away from the disc a tangential pull is exerted upon the same, and the action being constantly repeated, a more or less rapid rotation of the disc is the result. As the pull is exerted mainly upon

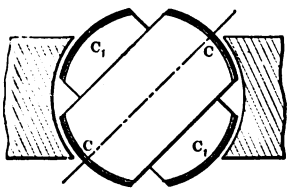


Fig. 6.

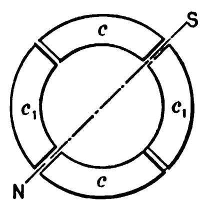


Fig. 6 a.

that part which is nearest to the ring, the rotation outside and inside, or right and left, respectively, is in opposite directions, figure 9. When placed symmetrically to the ring, the pull on opposite sides of the disc being equal, no rotation results. The action is based on the magnetic inertia of the iron; for this reason a disc of hard steel is much more affected than a disc of soft iron, the latter being capable of very rapid variations of magnetism. Such a disc has proved to be a very useful instrument in all these investigations, as it has enabled me to detect any irregularity in the action. A curious effect is also produced upon iron filings. By placing some upon a paper and holding them externally quite close to the ring they are set in a vibrating motion, remaining in the same place, although the paper may be moved back and forth; but in lifting the paper to a certain height which seems to be dependent on the intensity of the poles and the speed of rotation, they are thrown away in a direction always opposite to the supposed movement of the poles. If a paper with filings is put flat upon the ring and the current turned on suddenly, the existence of a magnetic whirl may be easily observed.

To demonstrate the complete analogy between the ring and a revolving magnet, a strongly energized electro-magnet was rotated by mechanical power, and phenomena identical in every particular to those mentioned above were observed.

Obviously, the rotation of the poles produces corresponding inductive effects and may be utilized to generate cur-

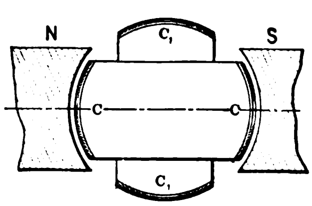


Fig. 7.

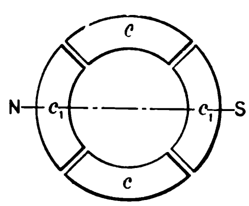


Fig. 7 a.

rents in a closed conductor placed within the influence of the poles. For this purpose it is convenient to wind a ring with two sets of superimposed coils forming respectively the primary and secondary circuits, as shown in figure 10. In order to secure the most economical results the magnetic circuit should be completely closed, and with this object in view the construction may be modified at will.

The inductive effect exerted upon the secondary coils will be mainly due to the shifting or movement of the magnetic action; but there may also be currents set up in

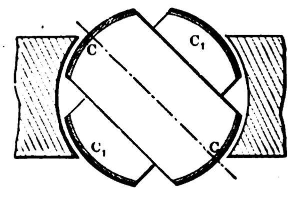


Fig. 8.

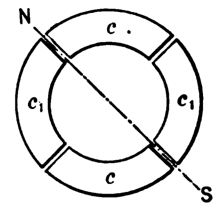


Fig. 8 a.

the circuits in consequence of the variations in the intensity of the poles. However, by properly designing the generator and determining the magnetizing effect of the primary coils, the latter element may be made to disappear. The intensity of the poles being maintained constant, the action of the apparatus will be perfect, and the same result will be secured as though the shifting were effected by means of a commutator with an infinite number of bars. In such case the theoretical relation between the energizing effect of each set of primary coils and their resultant magnetizing effect may be expressed by the equation of a circle having its centre coinciding with that of an orthogonal system of axes, and in which the radius represents the resultant and the co-ordinates both of its components. These are then respectively the sine and cosine of the angle α between the radius and one of the axes (OX). Referring to figure 11, we have $r^2 = x^2 + y^2$; where $x = r \cos \alpha$, and $y = r \sin \alpha$.

Assuming the magnetizing effect of each set of coils in the transformer to be proportional to the current—which

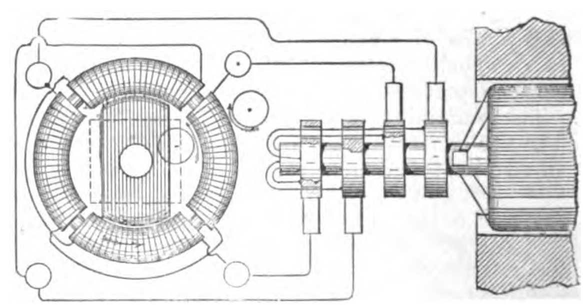


Fig. 9.

may be admitted for weak degrees of magnetization—then $x = Kc$ and $y = Kc^1$, where K is a constant and c and c^1 the current in both sets of coils respectively. Supposing, further, the field of the generator to be uniform, we have for constant speed $c^1 = K^1 \sin \alpha$ and $c = K^1 \sin (90° + \alpha) = K^1 \cos \alpha$, where K^1 is a constant. See figure 12.

Therefore,
$$x = Kc = KK^1 \cos \alpha;$$
$$y = Kc^1 = KK^1 \sin \alpha, \text{ and}$$
$$KK^1 = r.$$

That is, for a uniform field the disposition of the two coils at right angles will secure the theoretical result, and the intensity of the shifting poles will be constant. But from $r^2 = x^2 + y^2$ it follows that for $y = 0$, $r = x$; it follows that the joint magnetizing effect of both sets of coils should be equal to the effect of one set when at its maximum action. In transformers and in a certain class of motors the fluctuation of the poles is not of great importance, but in another class of these motors it is desirable to obtain the theoretical result.

In applying this principle to the construction of motors, two typical forms of motor have been developed. First, a form having a comparatively small rotary effort at the start, but maintaining a perfectly uniform speed at all

loads, which motor has been termed synchronous. Second, a form possessing a great rotary effort at the start, the speed being dependent on the load.

These motors may be operated in three different ways: 1. By the alternate currents of the source only. 2. By a combined action of these and of induced currents. 3. By the joint action of alternate and continuous currents.

The simplest form of a synchronous motor is obtained by winding a laminated ring provided with pole projections with four coils, and connecting the same in the manner before indicated. An iron disc having a segment cut away on each side may be used as an armature. Such a motor is shown in figure 9. The disc being arranged to rotate freely within the ring in close proximity to the projections, it is evident that as the poles are shifted it will, owing to its tendency to place itself in such a position as to embrace the greatest number of the lines of force, closely follow the movement of the poles, and its motion will be synchronous with that of the armature of the generator; that is, in the peculiar disposition shown in figure 9, in which the armature produces by one revolution two current impulses in each of the circuits. It is evident that if, by one revolution of the armature, a greater number of impulses is produced, the speed of the motor will be correspondingly increased. Considering that the attraction exerted upon the disc is greatest when the same is in close proximity to the

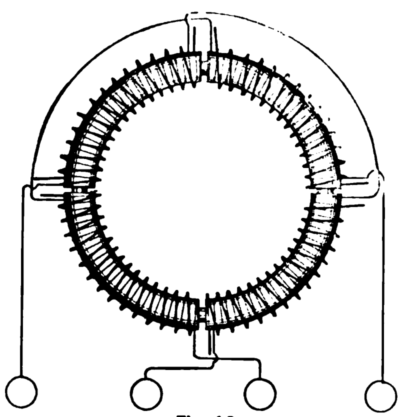


Fig. 10.

poles, it follows that such a motor will maintain exactly the same speed at all loads within the limits of its capacity.

To facilitate the starting, the disc may be provided with a coil closed upon itself. The advantage secured by such a coil is evident. On the start the currents set up in the coil strongly energize the disc and increase the attraction exerted upon the same by the ring, and currents being generated in the coil as long as the speed of the armature is inferior to that of the poles, considerable work may be performed by such a motor even if the speed be below normal. The intensity of the poles being constant, no currents will be generated in the coil when the motor is turning at its normal speed.

Instead of closing the coil upon itself, its ends may be connected to two insulated sliding rings, and a continuous current supplied to these from a suitable generator. The proper way to start such a motor is to close the coil upon itself until the normal speed is reached, or nearly so, and then turn on the continuous current. If the disc be very strongly energized by a continuous current the motor may not be able to start, but if it be weakly energized, or generally so that the magnetizing effect of the ring is preponderating it will start and reach the normal speed. Such a motor will maintain absolutely the same speed at all loads. It has also been found that if the motive power of the generator is not excessive, by checking the motor the speed of the generator is diminished in synchronism with that of the motor. It is characteristic of this form of motor that it cannot be reversed by reversing the continuous current through the coil.

The synchronism of these motors may be demonstrated experimentally in a variety of ways. For this purpose it is best to employ a motor consisting of a stationary field magnet and an armature arranged to rotate within the same, as indicated in figure 13. In this case the shifting of the poles of the armature produces a rotation of the latter in the opposite direction. It results therefrom that when the normal speed is reached, the poles of the armature assume fixed positions relatively to the field magnet and the same

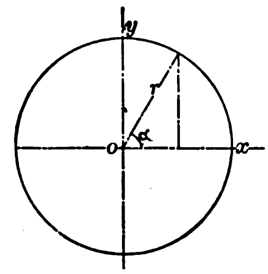


Fig. 11.

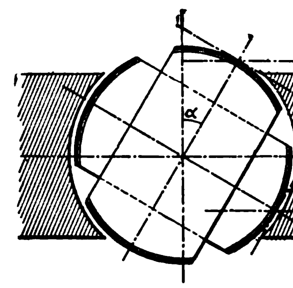


Fig. 12.

is magnetized by induction, exhibiting a distinct pole on each of the pole-pieces. If a piece of soft iron is approached to the field magnet it will at the start be attracted with a rapid vibrating motion produced by the reversals of polarity of the magnet, but as the speed of the armature increases the vibrations become less and less frequent and finally entirely cease. Then the iron is weakly but permanently attracted, showing that the synchronism is reached and the field magnet energized by induction.

The disc may also be used for the experiment. If held quite close to the armature it will turn as long as the speed of rotation of the poles exceeds that of the armature; but when the normal speed is reached, or very nearly so, it ceases to rotate and is permanently attracted.

A crude but illustrative experiment is made with an incandescent lamp. Placing the lamp in circuit with the continuous current generator, and in series with the magnet coil, rapid fluctuations are observed in the light in consequence of the induced currents set up in the coil at the start; the speed increasing, the fluctuations occur at longer intervals, until they entirely disappear, showing that the motor has attained its normal speed.

A telephone receiver affords a most sensitive instrument; when connected to any circuit in the motor the synchronism may be easily detected on the disappearance of the induced currents.

In motors of the synchronous type it is desirable to

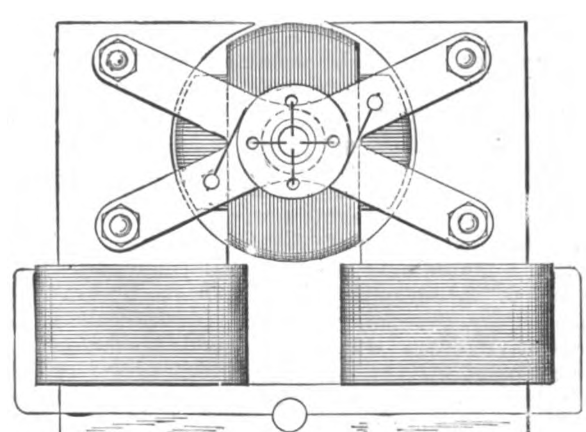


Fig. 13.

maintain the quantity of the shifting magnetism constant, especially if the magnets are not properly subdivided.

To obtain a rotary effort in these motors was the subject of long thought. In order to secure this result it was necessary to make such a disposition that while the poles of one element of the motor are shifted by the alternate

currents of the source, the poles produced upon the other element should always be maintained in the proper relation to the former, irrespective of the speed of the motor. Such a condition exists in a continuous current motor; but in a synchronous motor, such as described, this condition is fulfilled only when the speed is normal.

The object has been attained by placing within the ring a properly subdivided cylindrical iron core wound with several independent coils closed upon themselves. Two coils at right angles as in figure 14, are sufficient, but a greater number may be advantageously employed. It results from this disposition that when the poles of the ring are shifted, currents are generated in the closed armature coils. These currents are the most intense at or near the points of the greatest density of the lines of force, and their effect is to produce poles upon the armature at right angles to those of the ring, at least theoretically so; and since this action is entirely independent of the speed—that is, as far as the location of the poles is concerned—a continuous pull is exerted upon the periphery of the armature. In many respects these motors are similar to the continuous current motors. If load is put on, the speed, and also the resistance of the motor, is diminished and more current is made to pass through the energizing coils, thus increasing the effort. Upon the load being taken off, the counter-electromotive force increases and less current passes through the primary or energizing coils. Without any load the speed is very nearly equal to that of the shifting poles of the field magnet.

It will be found that the rotary effort in these motors fully equals that of the continuous current motors. The effort seems to be greatest when both armature and field magnet are without any projections; but as in such dispositions the field cannot be very concentrated, probably the best results will be obtained by leaving pole projections on one of the elements only. Generally, it may be stated that the projections diminish the torque and produce a tendency to synchronism.

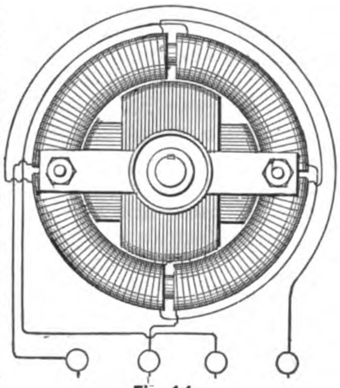


Fig. 14.

A characteristic feature of motors of this kind is their capacity of being very rapidly reversed. This follows from the peculiar action of the motor. Suppose the armature to be rotating and the direction of rotation of the poles to be reversed. The apparatus then represents a dynamo machine, the power to drive this machine being the momentum stored up in the armature and its speed being the sum of the speeds of the armature and the poles. If we now consider that the power to drive such a dynamo would be very nearly proportional to the third power of the speed, for this reason alone the armature should be quickly reversed. But simultaneously with the reversal another element is brought into action, namely, as the movement of the poles with respect to the armature is reversed, the motor acts like a transformer in which the resistance of the secondary circuit would be abnormally diminished by producing in this circuit an additional electromotive force. Owing to these causes the reversal is instantaneous.

If it is desirable to secure a constant speed, and at the same time a certain effort at the start, this result may be easily attained in a variety of ways. For instance, two armatures, one for torque and the other for synchronism, may be fastened on the same shaft, and any desired preponderance may be given to either one, or an armature may be wound for rotary effort, but a more or less pronounced tendency to synchronism may be given to it by properly constructing the iron core; and in many other ways.

As a means of obtaining the required phase of the currents in both the circuits, the disposition of the two coils at right angles is the simplest, securing the most uniform action; but the phase may be obtained in many other ways, varying with the machine employed. Any of the dynamos at present in use may be easily adapted for this

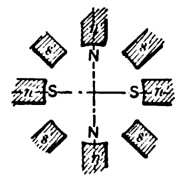


Fig. 15.

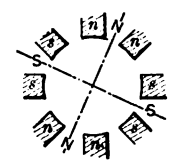


Fig. 16.

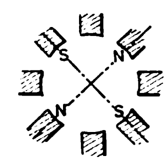


Fig. 17.

purpose by making connections to proper points of the generating coils. In closed circuit armatures, such as used in the continuous current systems, it is best to make four derivations from equi-distant points or bars of the commutator, and to connect the same to four insulated sliding rings on the shaft. In this case each of the motor circuits is connected to two diametrically opposite bars of the commutator. In such a disposition the motor may also be operated at half the potential and on the three-wire plan, by connecting the motor circuits in the proper order to three of the contact rings.

In multipolar dynamo machines, such as used in the converter systems, the phase is conveniently obtained by winding upon the armature two series of coils in such a manner that while the coils of one set or series are at their maximum production of current, the coils of the other will be at their neutral position, or nearly so, whereby both sets of coils may be subjected simultaneously or successively to the inducing action of the field magnets.

Generally the circuits in the motor will be similarly disposed, and various arrangements may be made to fulfill the requirements; but the simplest and most practicable is to arrange primary circuits on stationary parts of the motor, thereby obviating, at least in certain forms, the employment of sliding contacts. In such a case the magnet coils are connected alternately in both the circuits; that is, 1, 3, 5......in one, and 2, 4, 6......in the other, and the coils of each set of series may be connected all in the same manner, or alternately in opposition; in the latter case a motor

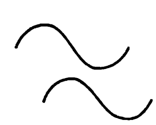


Fig. 18.

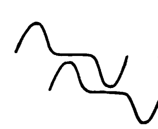


Fig. 19.


Fig. 20.

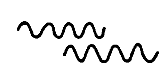


Fig. 21.

with half the number of poles will result, and its action will be correspondingly modified. The figures 15, 16 and 17, show three different phases, the magnet coils in each circuit being connected alternately in opposition. In this case there will be always four poles, as in figures 15 and 17, four pole projections will be neutral, and in figure 16 two adjacent pole projections will have the same polarity. If the coils are connected in the same manner there will be eight alternating poles, as indicated by the letters *n′ s′* in figure 15.

The employment of multipolar motors secures in this system an advantage much desired and unattainable in the continuous current system, and that is, that a motor may be made to run exactly at a predetermined speed irrespective of imperfections in construction, of the load, and, within certain limits, of electromotive force and current strength.

In a general distribution system of this kind the following plan should be adopted. At the central station of supply a generator should be provided having a consider-

able number of poles. The motors operated from this generator should be of the synchronous type, but possessing sufficient rotary effort to insure their starting. With the observance of proper rules of construction it may be admitted that the speed of each motor will be in some inverse proportion to its size, and the number of poles should be chosen accordingly. Still exceptional demands may modify this rule. In view of this, it will be advantageous to provide each motor with a greater number of pole projections or coils, the number being preferably a multiple of two and three. By this means, by simply changing the connections of the coils, the motor may be adapted to any probable demands.

If the number of the poles in the motor is even, the action will be harmonious and the proper result will be obtained; if this is not the case the best plan to be followed is to make a motor with a double number of poles and connect the same in the manner before indicated, so that half the number of poles result. Suppose, for instance, that the generator has twelve poles, and it would be desired to obtain a speed equal to $\frac{12}{7}$ of the speed of the generator. This would require a motor with seven pole projections or magnets, and such a motor could not be properly connected in the circuits unless fourteen armature coils would be provided, which would necessitate the employment of sliding contacts. To avoid this the motor should be provided with fourteen magnets and seven connected in each circuit, the magnets in each circuit alternating among themselves. The armature should have fourteen closed coils. The action of the motor will not be quite as perfect as in the case of an even number of poles, but the drawback will not be of a serious nature.

However, the disadvantages resulting from this unsymmetrical form will be reduced in the same proportion as the number of the poles is augmented.

If the generator has, say, n, and the motor n_1 poles, the speed of the motor will be equal to that of the generator multiplied by $\frac{n}{n_1}$.

The speed of the motor will generally be dependent on the number of the poles, but there may be exceptions to this rule. The speed may be modified by the phase of the currents in the circuits or by the character of the current impulses or by intervals between each or between groups of impulses. Some of the possible cases are indicated in the diagrams, figures 18, 19, 20 and 21, which are self-explanatory. Figure 18 represents the condition generally existing, and which secures the best result. In such a case, if the typical form of motor illustrated in figure 9 is employed, one complete wave in each circuit will produce one revolution of the motor. In figure 19 the same result will be effected by one wave in each circuit, the impulses being successive; in figure 20 by four, and in figure 21 by eight waves.

By such means any desired speed may be attained; that is, at least within the limits of practical demands. This system possesses this advantage besides others, resulting from simplicity. At full loads the motors show an efficiency fully equal to that of the continuous current motors. The transformers present an additional advantage in their capability of operating motors. They are capable of similar modifications in construction, and will facilitate the introduction of motors and their adaptation to practical demands. Their efficiency should be higher than that of the present transformers, and I base my assertion on the following:—

In a transformer as constructed at present we produce the currents in the secondary circuit by varying the strength of the primary or exciting currents. If we admit proportionality with respect to the iron core the inductive effect exerted upon the secondary coil will be proportional to the numerical sum of the variations in the strength of the exciting current per unit of time; whence it follows that for a given variation any prolongation of the primary current will result in a proportional loss. In order to obtain rapid variations in the strength of the current, essential to efficient induction, a great number of undulations are employed. From this practice various disadvantages result. These are, increased cost and diminished efficiency of the generator, more waste of energy in heating the cores, and also diminished output of the transformer, since the core is not properly utilized, the reversals being too rapid. The inductive effect is also very small in certain phases, as will be apparent from a graphic representation, and there may be periods of inaction, if there are intervals between the succeeding current impulses or waves. In producing a shifting of the poles in the transformer, and thereby inducing currents, the induction is of the ideal character, being always maintained at its maximum action. It is also reasonable to assume that by a shifting of the poles less energy will be wasted than by reversals.

THE PATENT COURT AND UNIFORMITY IN PATENT PRACTICE[1].

BY GEORGE H. STOCKBRIDGE.

In December, 1885, Mr. Montgomery, then Commissioner of Patents, rendered a decision in which he held that a process and a product, or any two "kindred and auxiliary" inventions might be claimed in the same application. This decision was a reversal of his predecessor's judgment in *ex parte Blythe* (C. D. 1885, page 82). Whereas Mr. Butterworth had held that by employing the language, "art, machine, manufacture, or composition of matter," Congress had defined in the law itself certain distinct classes of invention. Mr. Montgomery denies this, in effect, and holds as follows: "Inventions may be distinct and not separate and independent; even if so distinct, if they depend upon each other and mutually contribute to produce a single result, if they are 'kindred and auxiliary,' if they are in their nature or operation connected together, if they are connected in their design and operation, they may be claimed in one patent."

The office practice under Butterworth had been to deny the right of inventors to claim a process and a product, or a machine and a product, or a machine and a process (for these groups have always stood on the same footing) in the same application. The *Blythe* decision did not go so far as to warrant this in direct language, but it was given that scope by the office.

Now, when the Montgomery decision in the case of *Young* was published, all this was changed. This decision also was interpreted somewhat differently from what its language would justify, but it led to the practice of combining in a single application duplicate sets of claims on the lines indicated. This practice continued nearly two years. During that time applicants and their attorneys filed, we will say, a thousand cases having claims based upon the *Young* decision. This was done with the clearest warrant, which was the office interpretation of *ex parte Young*.

On Oct. 19, 1887, Mr. Hall, the present Commissioner of Patents, took up the same subject and rendered a decision *ex parte Herr* (41 O. G., page 463), in which he says: "It must be regarded as settled by the very highest authority that an apparatus and a process are separate and distinct inventions. There is no requirement of law that they must or ought to be comprehended in a single patent, while there are many reasons why they ought not to be. A claim for a machine or apparatus and a claim for a process should be prosecuted in separate applications, and each, when allowed, should be comprehended in a single patent." There was no mistaking the meaning of this language. The result of it was that attorneys were notified, in the thousand cases I have mentioned, that the

1. Read before the American Institute of Electrical Engineers, May 16, 1888.

claims, or some of them, which they had filed in good faith and in accordance with the practice of the office, must be stricken out.

A secondary result was that inventors began to ask what their attorneys meant. "You told us," they said, "that we could cover both sets of claims by a single patent. What do you mean, now? Is this an attempt to squeeze us for another fee?" Well, of course, we had to explain. But the inventors then asked, "What does the *Office* mean? Is it possible that after fifty years no settled practice on this point has become established?" We had to answer, No. And in answering my own clients, I was led to consider just how safely such a statement might be made, and the result was the present paper.

Mr. Commissioner Hall expresses it in this way: "I approach the consideration of such a question with the greatest hesitation. It is one that has kept the attention of the office from its foundation up to the present day, and during the entire period there have been constant changes and variations of opinion on the part of commissioners, contrariety of decisions and diversified rules."

I have not seen fit to go back farther than eighteen years, during which time there have been eleven commissioners of patents, and four or five acting-commissioners during the interegna. In 1870 Mr. Commissioner Fisher made a decision in case of *William Lowe* (C. D. 1870, page 39). In this case the inventor, who had been allowed claims for an apparatus, sought to obtain a second patent upon the process which was conducted through his apparatus. In deciding the case on appeal, Mr. Commissioner Fisher said: "The first answer to this claim is, that it cannot form a subject of a separate patent. It is not a distinct and separate part of the thing patented in the original. The farthest to which the division of inventions has been pushed has been to grant one patent for the process and another for the product of that process. Such patents have, with some hesitation, been sustained (*Goodyear* vs. *Honsinger*, 3 Fisher, 150; *Goodyear* vs. *Wait*, 3 Fisher, 244; *Goodyear* vs. *Providence Rubber Company*, 2 Fisher, 510), but upon the express ground that this was a matter confided by law to the discretion of the commissioner. But I have never known one patent to issue for the machine and another for the law and principle by which it operates. The mechanism of application is of no possible value except to carry out this process. Aside from this it possesses no patentable utility. The process is of no avail unless carried on through the medium of instrumentality. (*Morton* vs. *New York Eye Infirmary*, 2 Fisher, 324.) It would be idle to sell the patent for mechanism and withhold that which covers its legitimate and only mode of operation. Separate patents for processes and products have been justified upon the ground that the product might be imported, and a patent for the process would give no protection; but the machine and its mode of operation cannot be separated."

Mr. Fisher was a man of very positive opinion, and he leaves no doubt regarding his views on the subject. But the views of his immediate successor, Mr. Leggett, are very different from his. (See *Murray* vs. *Wuterich*, C. D. 1873, page 96). He draws diametrically opposite conclusions from Judge Clifford's decision in *Goodyear* vs. *Providence Rubber Company*. Admitting that the office practice allowed a "machine and its product to be claimed in the same application and go out in the same patent," he sums up as follows: "Notwithstanding the precedents which exist, and admitting that such a practice as they indicate, if not strictly correct, is not fatal to the validity of patents, I think the time has come, when, leaving out of consideration the perspicuity of the patents themselves, and the revenue to be derived under the law for examinations, a proper classification in the office, so as to facilitate examinations and prevent mistakes in the issue of patents, requires that processes, machines and their products be presented for patent in separate applications."

Mr. Leggett resigned his office in October, 1874, and on the 23d of that month Acting-Commissioner Thatcher, in the case of Chamberlin (C. D. 1874, page 111), says: "All that can rightfully be claimed in this application is the machine and the link blank, which is the product of the machine." Here is plain evidence of difference of opinion. Mr. Thatcher evidently knows nothing about "a proper classification in the office, requiring that processes, machines and their products be presented for patent in separate applications."

I find no positive judgment of Thatcher on the subject, nor of the successor, Mr. Duell, although Duell deals with a case in which process and product claims are combined (Loeser, C. D., 1876, page 104) without adverse comment.

The next decision is that of Doolittle, Acting-Commissioner in 1877, in which he demands a division of the application of *Junker* and *Wolf*, on the ground that "the article is not necessarily the result or product of the action of the machine." This is in some sense a forerunner of Mr. Commissioner Spear's decision in 1878, which introduced a mode of treating such cases which prevailed for several years after him. His language is: "No rule of universal application can be given for this class of cases, more than for any other; but in each case, as it comes up for consideration, the inquiry must be made whether the process or machine and the products thereof are so separate and distinct that they must be called independent inventions."

This doctrine was affirmed by Mr. Paine in various decisions, notably in *Winterlich and others*, where he uses this language: "If the machine and the manufacture are so related that the former cannot operate without producing the latter and the latter can only be produced by the former, both may be united in one patent; but this is an exception to the general rule, which forbids the joinder of the machine and its product in one application.

Mr. Commissioner Marble, in *Bancroft* and *Thorn* (20, O. G., page 1,894), applauds the doctrine of his immediate predecessor and lets each case stand upon its own merits. Then came the Butterworth decision to which I have already alluded. He regards art, machine, manufacture and composition of matter as "statutory classes of invention." "Suppose," he adds, "there be invented something in an art, or, as it is ordinarily called, a process, also a machine for carrying out the process, and also the manufacture or article which is produced in the operation of the process by the machine. There can be no doubt but that the statute calls for three patents for these three things. It makes no difference if they are invented simultaneously or successively, by one man or by three. Their independence remains the same."

Now let us see what changes of practice have been introduced by the various decisions to which reference has been made.

Mr. Fisher's decision seems to have been a new departure and to have altered the previous practice of the office. At all events, it fixed the practice under his administration and made it a positive requirement to combine claims for a machine and its product in the same application.

Well, what happens next? Mr. Leggett demands that such claim shall be separated, to facilitate the work of examination. That is change No. 2.

Mr. Thatcher and Mr. Duell appear to have allowed the two sets of claims to be combined, though I find no decision of theirs directly on the point. If I judge rightly of their practice, it may be regarded as constituting change No. 3.

It is certain that Mr. Spear and his successors, Mr. Paine and Mr. Marble, followed the practice of settling each case according to its own circumstances. Call this change No. 4.

Mr. Butterworth returned, in effect, to the practice of Mr. Leggett (change No. 5); Mr. Montgomery, in effect, followed Fisher (change No. 6), and Mr. Hall has now brought back the Leggett decision, thus introducing again

a different practice from that of his predecessor in office (change No. 7).

I believe that if each commissioner had made himself the author of a new practice, there would have been three more changes than have actually taken place. However, I do not think more could have been expected; really, this is a very serious matter. The amount of annoyance and hardship imposed upon inventors in the way of unnecessary delay and expense is in the aggregate very great. I have no disposition to express an opinion as to which one, or whether any one, of the commissioners has been right in his judgment on the matter in question. I have no doubt that the decisions in every case have been drawn up with a conscientious regard to the responsibility of the office from which the decisions emanated. But I do think that inventors and all who are interested in inventions have a right to protest against the continuance of a system which admits of and invites such unjust and arduous practices. It would not matter so much what the practice was, provided it were uniform, although of course it ought to be right and fair to inventors. But without uniformity it is monstrously unjust.

Lest it be thought that I have selected a peculiar class of cases, I may hasten to deny it in advance and may add that the office practice has been frequently altered on many matters quite as important. Take, for example, the question whether more than a single claim may be made in an application for a patent on a composition of matter. At least two commissioners have answered, No, and at least two more have answered, Yes. And so with many other cases. The mere fact that appeals have been taken to successive commissioners on the same subject indicate the condition of affairs in the office.

What is the remedy for this evident evil? The best remedy yet proposed I conceive to be embodied in the bills recently laid before Congress by the Legal Committee of the National Electric Light Association. One of these bills provides that the salary of the Commissioner of Patents shall be $8,000 a year. I am not sure that the enactment of such a bill would not do away with two-thirds of the evils of the present state of affairs. It is probable at least that we should not have eleven Commissioners of Patents in eighteen years, if the salary were $8,000, and with less frequent changes in the head of the office there would be necessarily less frequent changes in the office practice.

But there is still greater promise in the other bill which provides for the establishment of a Court of Patent Appeals, which shall have appellate jurisdiction from the Commissioner of Patents "in all cases touching patentability of inventions, priority of invention among several claimants for patent on the same invention, and the *judicial practice of the Patent Office.*"

Such a court would be in the nature of the case a continuing body, and its decisions would be little liable to change. The enactment of the last clause quoted would give it authority and set up what has never been set up before in connection with the Patent Office—a controlling and continuing authority, governing the actions of the commissioner and, through him, of the primary examiners.

A SWINGING ARM GALVANOMETER.[1]

BY GEORGE S MOLER, A. B., B. M. E.

(Cornell University.)

The objects sought in the construction of this galvanometer were applicability to a great range of currents, accuracy of indication and portability. In passing from the measurement of large to that of small currents no change in the apparatus is necessary, and still throughout a wide range great sensitiveness is maintained.

These ends are attained by making use of the fact that the influence of a current on the magnetic needle varies with change of distance and with the angle which the plane of the coil makes with the horizon. The principles of the sliding coil galvanometer and of Obach's cosine galvanometer are thus combined. A movable arm is hinged to the base of the galvanometer, figure 1, and carries the coil, which is attached to its outer end. The length of the arm is such that in the vertical plane the needle will be in the axis of the coil. By means of screw clamps, the hinges are made to produce friction enough to hold the arm in any required position.

When the coil is brought up into the vertical plane it is very near the needle and a small current will produce a deflection. In this position, which is that of maximum sensitiveness (since the distance is a maximum and the angle which the coil makes with the horizontal plane is 90°), $\frac{1}{100}$th of an ampere produces a deflection of about 8 mm.

As the arm is carried down toward the horizontal position, greater and greater currents must be employed to produce the same effect. The position of the coil can be read upon a graduated quadrant which passes through it, there being a pointer attached to the coil and extending inward to the graduations.

The arm consists of two parallel bars of copper, terminating in the two hinges. These are insulated from each

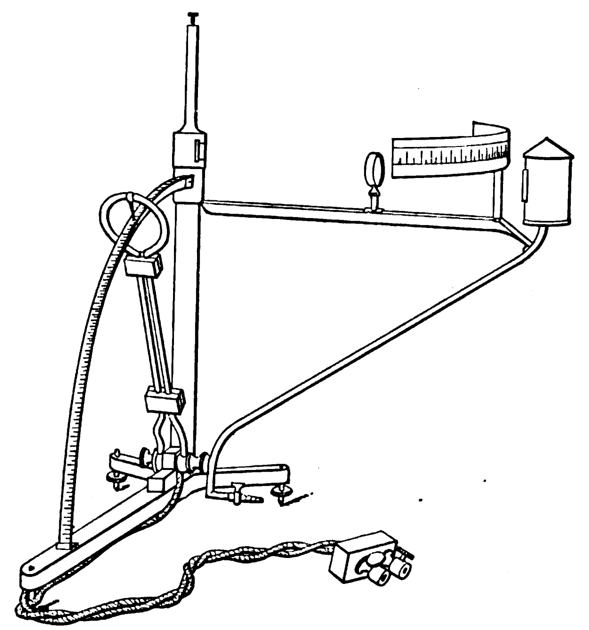


Fig. 1.

other, and from them two flexible conductors are carried to the extremity of the base; after that they are twisted together for a distance of about one meter and end in a block to which two large binding-posts are attached.

The coil is made of a copper rod 8.5 mm. thick, and its outside diameter is 76.5 mm. The radius of the graduated quadrant is 343 mm. and it is divided into twentieths of an inch. The radius of the lamp-scale is 381 mm. The scale forms the arc of a circle, having the galvanometer mirror for a centre. Its length is 500 mm., and it is composed of paper, rendered semi-transparent by being treated with castor oil.

The needle is shown in figure 2. It is a bell-shaped magnet carrying a mirror, which can be rotated slightly upon the suspension rod for the sake of adjustment.

The needle is suspended by means of a fine silk fibre, and is prevented from making a complete revolution by means of a stop. Its motions are dampened in the usual manner by the action of a surrounding cylinder of copper.

The rays of light from a small gas lamp, shown in figure 1, after passing through a lens, are reflected from the

1. Read before the American Institute of Electrical Engineers, by Professor E. G. Nichols.

mirror and then fall upon the scale. When the plane of the swinging coil is in the magnetic meridian and no current is flowing, the spot of light will fall at the centre of the scale. The lamp and scale are attached rigidly to the body of the instrument for the sake of rigidity and to avoid the necessity of repeated calibrations. In the lamp case is a small circular opening having a fine vertical cross-hair of platinum, and the lens is so placed that the image of the cross-hair is sharply defined upon the scale. All parts of the scale being equally distant from the mirror, as shown in figure 1, the definition of this image is equally good for all deflections.

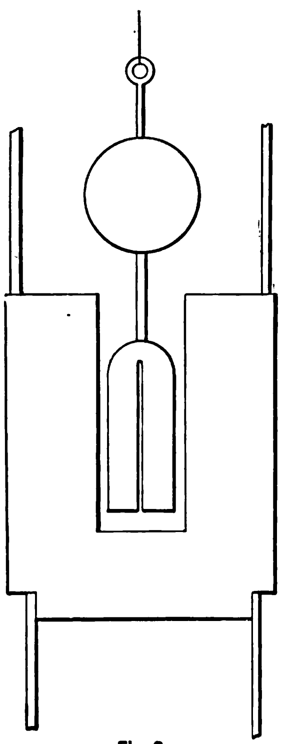


Fig. 2.

The swinging-arm galvanometer is especially designed to be used with the method of constant deflections. By carrying the coil up from the horizontal position, the spot of light will be deflected more and more, until the image of the cross-hair is made to coincide with the chosen mark upon the scale; the position of the coil is then to be read and the current found by reference to a calibration curve or chart. In the measurement of feeble currents, the chosen point on the lamp-scale may be near the position of no deflection, while for stronger currents it may be further away. Several deflection points may be thus chosen and a calibration by means of some standard instrument can be made for each; then, to insure greater accuracy in the determination of a current, several of these points may be used, and the mean of the currents indicated by them may be taken, giving to each its proper weight.

The instrument may also be used by taking different fixed positions for the coil and reading the deflections of the spot of light, calibrating for each of these positions as before. These two methods may also be combined by moving the coil until the spot of light is approximately in coincidence with a selected deflection point, observing its

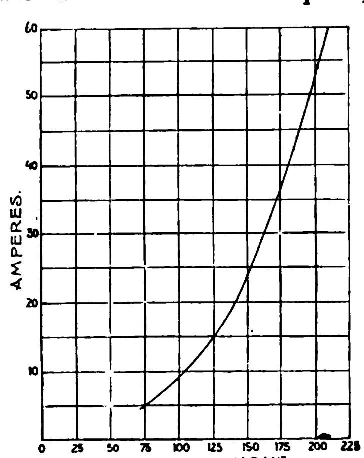


Fig. 3.

distance from the same and applying to the current value, by means of the previously determined figure of merit, the proper correction. In this way changes in a slightly fluctuating current can be followed and measured by moving the coil.

In order to indicate heavy currents to an audience in a lecture room it is only necessary to remove the lamp stand and scale and so make use of the stronger light of the magic lantern; the image of a slit in the field of the lantern, after reflection from the galvanometer mirror, being thrown upon a wall or screen. A position of the coil can then instantly be found which will produce suitable deflections for any given current, from a fraction of one ampere up to that which the coil and connections can be made to convey without destruction from heating.

In the curve, figure 3, and the accompanying table are given the results of a calibration of a galvanometer of the pattern just described, which has just been constructed in the department of physics in Cornell University.

The deflection selected was 10 cm., and the measurements, which extended from 3 amperes to 60 amperes, by no means covered the possible range of the instrument. The movement of the coil indeed covered only 200 of the 400 scale divisions into which the reading quadrant is divided.

The calibrations were made in the magnetic observatory of the university, in which locality the average value of the earth's horizontal intensity is .1713. The currents were measured upon the great tangent galvanometer.

Simultaneous readings were made upon that instrument and upon the swinging-arm galvanometer.

The readings of the great galvanometer, reduced to amperes, with the corresponding positions of the swinging coil for a deflection of 10 cm. are given in the following table:—

Calibration of the swinging-arm galvanometer between 5 amperes and 60 amperes constant deflection = 10 cm.

Current in amperes (large galvanometer).	Quadrant readings (swinging-arm galvanometer).	Current in amperes (large galvanometer).	Quadrant readings (swinging-arm galvanometer).
5.21	79.0	19.48	138.0
5.54	79.5	24.42	151.0
5.84	82.0	24.48	151.5
8.04	95.8	32.00	167.0
10.35	106.0	33.44	168.5
10.39	107.0	33.99	171.0
10.86	110.0	38.50	179.5
11.53	110.0	42 79	185.0
13.25	119.0	43.90	187.0
13.92	119.5	46.14	191.0
15.25	125.0	53.56	202.0
19 39	137.5	59.39	208 0

From these values, with the readings of the new galvanometer as abscissæ and currents in amperes as ordinates, the curve shown in figure 3 has been constructed.

From this curve the currents for intermediate positions of the coil may be determined and the degree of accuracy of which the instrument is capable may be estimated.

UNDERGROUND ELECTRICAL CONDUCTORS IN EUROPE AND AMERICA.[1]

BY PROFESSOR G. W. PLYMPTON.

The problems of construction of underground systems of electrical conduction will have been solved when the telephone and the arc light systems are both buried under our streets without impairing the efficiency or durability of either.

By this I mean that all the difficulties encountered in burying conductors are involved in converting telephone and arc light from *aerial* to *underground* systems. Telegraph lines and systems of incandescent lighting present fewer difficulties in the process of burying, and none of a kind not met with in dealing with the systems first mentioned.

The telephone problem is substantially solved. Some

1. Read before the American Institute of Electrical Engineers, May 16, 1888.

details only remain to be settled, among which may be mentioned the best size of conductor, the most serviceable insulation, and the maximum distance of effective service for either grounded or metallic circuits.

In Brooklyn the general plan adopted is that of a conduit divided into ducts through which cables containing from sixty to one hundred wires are drawn. The material of the conduit is for the most part creosoted wood. About ten miles of this is already in use in our city, and about four and a half miles of the Dorsett concrete conduit. For the extensions of the underground systems for the present year, only creosoted timber is to be used.

Among the lessons learned from our experience are: 1st—That in creosoted conduits the use of cables covered with kerite, or any similar rubber or gutta-percha compound, must be avoided. 2d—That in the so-called lead covered cables, the use of pure lead is also to be avoided, as it is slowly converted into a porous and friable lead carbonate. An alloy of lead with five or six per cent. of tin seems to resist the destructive action. 3d—That the conducting wire first used is too small for satisfactory telephone service. The difficulties of induction and retardation led to complaints as soon as 4,000 or 5,000 feet of underground wire was put in service. The cables that are now being put in are made up of wires whose cross-section is greater by one-third than that of the first wire, and they are protected by twice the thickness of insulation.

I mention the above conclusions as having been drawn from our own experience in Brooklyn.

In commencing our work we gathered such information as could be gleaned from localities where solutions of the problem had already been attempted. The impression so largely prevailed that in Europe all telephone and telegraph conductors were underground that our board decided that a personal inspection of European systems should be made by one of our number. The duty devolved upon me. The result of my inquiry has been published in the scientific papers.

I will briefly refer to a few of the incidents (Professor Plympton here gave an epitome of the third annual report of Brooklyn subway commission, which embodied his observations).

In regard to the burial of the arc light wires I can only say that no method yet tried seems certain of success. Most of them certainly insure the destruction of the underground conductors in from one to three years. But I have no doubt that a solution of the problem will soon be reached, although the system will be kept apart from the telephone and telegraph subway.

It does not seem likely that arc light conductors will be allowed in the same conduit with telephone wires, nor will they be distributed from the same man-holes.

In saying that, I believe that a solution of the problem will soon be found. I do not mean to assert that casualties like that recently recorded of a man in the Bowery, who lost his life by grasping the naked wire close to an arc lamp, can be prevented by any system of burying wires. To prevent such *accidents* (if that is the term to be used) the arc lights must be buried with the wires.

All past experience teaches us to proceed cautiously. Nothing can now permanently check the growth of the telephone, the telegraph or the electric light. They have become necessities of our civilization, and any hasty or ill-advised enforcement of the law to convert all aerial to underground systems which should result in serious injury to them, would prove the surest way to perpetuate the nuisances of overhead wires and poles in the streets.

.... THE strong points of the average executive committee of an electrical corporation are, an innocence of electrical knowledge; an inability to distinguish between the two words "economy" and "parsimony," and an indisposition to see that a dollar properly expended to-day means a good many saved throughout the year.—*Thomas D. Lockwood.*

ABSTRACTS AND EXTRACTS.

ELECTROLYSIS OF IRON SALTS.

BY ALEXANDER WATT.

(Continued from page 176.)

Double Carbonate of Sesquioxide of Iron and Soda.—In this experiment it was desired to ascertain what kind of a deposit would be obtained from an alkaline solution. To form the electrolyte, a strong solution of bicarbonate of soda was first prepared, into which freshly precipitated carbonate of iron was gradually introduced, and the mixture well stirred. When it was found that the soda solution had taken up as much of the iron salt as it was capable of doing, the vessel was set aside for an hour or so, and the clear liquor then decanted off for use. The current from five Daniells was employed, and a copper cathode as before. In a few moments after immersion the copper plate became coated with a fine white deposit of iron. There was a brisk evolution of gas at both electrodes, and after a short time the solution acquired a brownish tint; the bath, however, continued to yield good deposits of iron for a considerable time, and the anode kept remarkably clean.

Sodio-Citrate of Iron.—A solution of this salt was prepared by dissolving recently precipitated carbonate of iron in a hot and strong solution of citric acid, and then adding carbonate of soda. The solution was next diluted with about two parts of water. With a current from five cells a metallic deposit was obtained at once upon a strip of copper, but this quickly assumed the color of "blued" steel, for an instant only, however, when it again acquired the characteristic color of metallic iron; the deposit, which chiefly occupied the lower surface of the plate, refused to cover the surface nearest the top of the fluid.

Acetates of Iron and Soda.—The electrolyte was formed by dissolving recently precipitated and moist carbonate of iron in acetic acid to saturation; the solution was then diluted with twice its bulk of water; acetate of soda was then dissolved in the liquid, and the solution was ready for use. The current from five small Daniells, in series, was employed, and a copper plate used as the cathode. Immediately after immersing the receiving plate it became coated with a bright and silvery white film of iron, the deposition taking place very uniformly, and the coating well retaining its character. There was a moderate evolution of gas, and the anode remained clean and bright.

Potassio-Citrate of Iron.—A solution of this salt was made by dissolving recently precipitated and moist carbonate of iron, prepared with carbonate of potash, in a strong and hot solution of citric acid. The citrate solution thus obtained was then neutralized with carbonate of potash, and was then tried in its concentrated form, when the receiving plate (a strip of sheet copper) soon became coated with a metallic film of a dark green color. The liquid was next diluted, and a fresh plate immersed, which at once received a coating of bright metal, but not of so good a color as that obtained from the simple citrate of iron. The plate was allowed to remain stationary for a minute or two, when the dark green film again appeared upon its surface. A freshly-prepared plate was now substituted, and this was kept in brisk motion while in the bath, when a silvery white film was obtained which strongly adhered to the plate. The solution was now further diluted to see if a bright reguline deposit could be obtained upon a stationary plate. Such was not the case however, for shortly after a layer of white metal had been deposited, the coating again became covered with a dark green film. When a newly-prepared plate was immersed, and kept in rapid motion, the deposit was of a good reguline character, very white, and, as before, very strongly adherent. In working this solution it was noticed that the metallic deposit, as in some other cases, commenced at the upper portion of the cathode, gradually proceeding downwards.

Chlorides of Iron and Potassium.—Solutions of the respective salts were mixed, and electrolyzed with a current from two small Daniells. Only a slight trace of metal appeared upon the upper part of the cathode, while a copious dark green salt was formed, which in a few minutes floated on the surface of the liquid to the depth of about half an inch.

Perchloride of Iron and Chloride of Potassium.—A solution of chloride of potash was added to one of perchloride of iron, and a current from two Daniells employed. A copper plate promptly became coated with a bright film of iron of good color in this solution, the anode surface being about one-half that of the cathode. There was a brisk evolution of gas, with which the solution soon became impregnated throughout. After a short immersion the plate became spotted in parts with minute dark specks, which were easily removed by scouring with silver sand. The plate being again returned to the bath received a further coating of white metal, which appeared to be exceedingly tough for electrolytic iron, for when a corner of the coated plate was turned down, forming a sharp bend, there was no evidence of the deposited metal having separated from the underlying surface of copper. It was noticed that the anode kept perfectly clean during the electrolysis. This result from a persalt of iron was highly satisfactory.

(*To be continued.*)

THE FRANKFURT-OFFENBACH ELECTRIC TRAMWAY.[1]

BY E. KRAUSE.

THIS tramway was constructed on the main road between Frankfurt and Offenbach on the Main, and has been in continuous operation during the last four years. Tram rails of the usual street railway pattern used, level with the road pavement.

The whole length of the line is 4.14 miles. It is a single track line, but there are short side tracks at the termini for shunting the carriages, and at three passing places, distributed at nearly equal distances over the whole length, dividing the line into four sections. This makes it possible to increase the working capacity of the line and to have two trains going up and two trains going down at the same time. There are at present nineteen stations. Many curves and gradients make the working of this line difficult; the stiffest incline is 1 to 32 for almost 100 yards distance, another 1 to 45 for 150 yards, with a curve of 110-feet radius. The gauge of the track is one meter.

The conductors are overhead. Slotted wrought iron tubes are used for conveying the electric current along the line. The tubes are of 1 in. internal diameter and $1\frac{5}{8}$ in. external diameter, and are slotted on the under side as shown, full size, in figure 1.

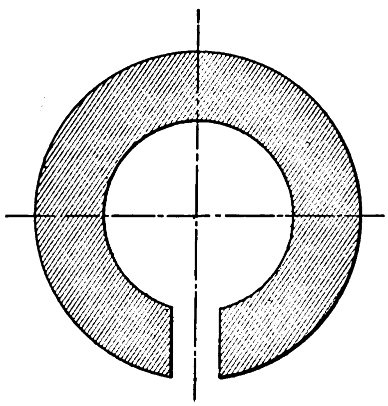


Fig. 1.

The length of the tubes is 15 feet; they are well bored out, and are perfectly smooth and clean, so that the internal surface offers as little mechanical or electrical resistance as possible to the contact carriage sliding within. The tubes are screwed together by means of sockets in the usual way and then soldered. About 90 feet apart, but much closer in curves, wooden poles are erected on one side of the road, on which cast-iron brackets, as shown in figure 2, are fastened. The brackets carry two iron-hooded insulators, on which the tubes are suspended by means of iron hooks. The poles are 18 feet high, and the tubes are placed about 15 feet from the ground. To prevent the suspended tubes from sagging two stout iron-wire ropes are stretched over insulators fastened on cast-iron brackets on the top of the poles all along the line, and the tube conductors have generally two supports between two poles, being attached by clamps, to the ropes as shown in figure 3. The expansion of the conductors during hot wêather causes more sagging than in cold weather, when the conductors are almost straight; this, however, does not appear to impede the moving contact carriage. The resistance of the whole line of tube conductors is only 1.6 ohm.

The three turn-out tracks necessitated the arranging of three passing places in the overhead conductors for the contact carriages of the two passing tramcars. This has been done in an ingenious manner, as shown in figure 4. The two parallel slotted tubes R and S are gradually bent, and where they would meet a part has been cut out and replaced by a well-seasoned piece of hard wood. The two tubes are partly let into it, and the bores and slots are cut through the wood. On the other end of the wooden piece H the tubes G and I, continue the conductors. Thus the four tubes are insulated one from the other, and the contact carriage can slide from tube R to I, or from G to S—in other words, can go up or down the line. To connect the positive leads S and G, and the negative conductors R and I, two metal pieces *m* and *n* are arranged above the wooden block H insulated from each other (*see* figure 5 in section), and screwed to the corresponding tubes. To complete the passing place for the conductors the tubes L and K are joined to the tubes S and R, as shown in figure 4. When the contact carriage goes up or down the line it is necessary to direct it into the right tubes, which is effected by two movable tongues, *t* and *z*, pivoted at *p*, and shown in figure 6 in section. These tongues are always kept in the position shown in figure 4 by means of springs (*see* figure 9), acting on the turned end of the tongue. If a contact piece slides in R to the left, it will easily go into tube I—the tongue closes the way into K—and if a contact piece in G moves to the right, it will slide into tube S, pressing the tongue *t* aside.

This arrangement requires the contact carriage to be constructed in such a way that while passing through the wood block

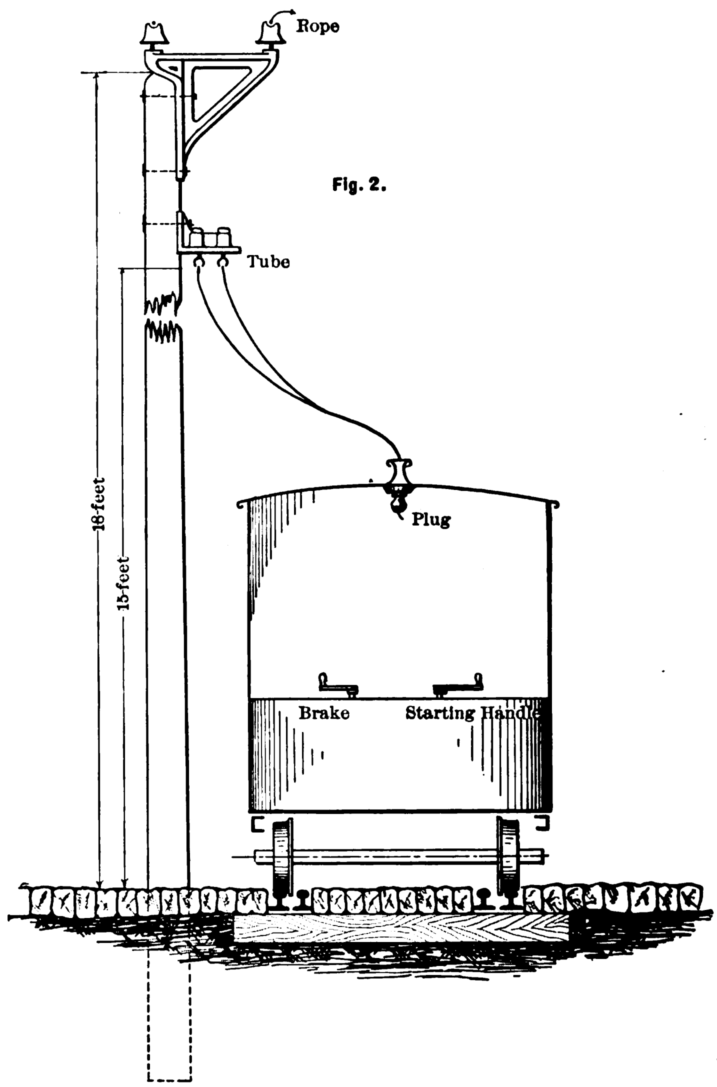


Fig. 2.

H the flow of current to the tramcar be not interrupted, and also that it follow with perfect ease the curves of the conductors. Figure 8 shows the tube conductor in longitudinal section and the contact carriage in elevation. Figure 9 is a side elevation. Within the tube slide two cast-iron pistons, C C, with pointed ends and flat projections below, B, fitting into the slots of the tubes. These projections are riveted to a steel band, A, of $\frac{3}{4}$ in. width and $\frac{1}{16}$ in. thickness, which carries in the middle a bent brass piece, D, screwed to it. Besides the steel band connection two

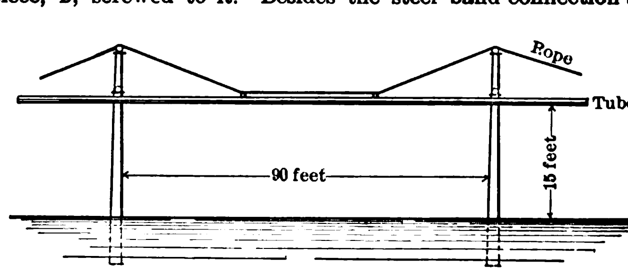


Fig. 3.

small copper wire ropes (not shown in figure 8) connect D to the right and left with the projections B, and securing a safe passage for the current. The brass piece D contains also the insulated copper wire conductor E, which is fastened to a rope, F, leading with the conductor E into the tramcar. On both ends of the steel band A are fastened two brass pieces carrying a steel rod, *d*, parallel to the tube conductor. Two metal pieces, *f*, screwed together

1. From *The Electrician*, London. Abridged.

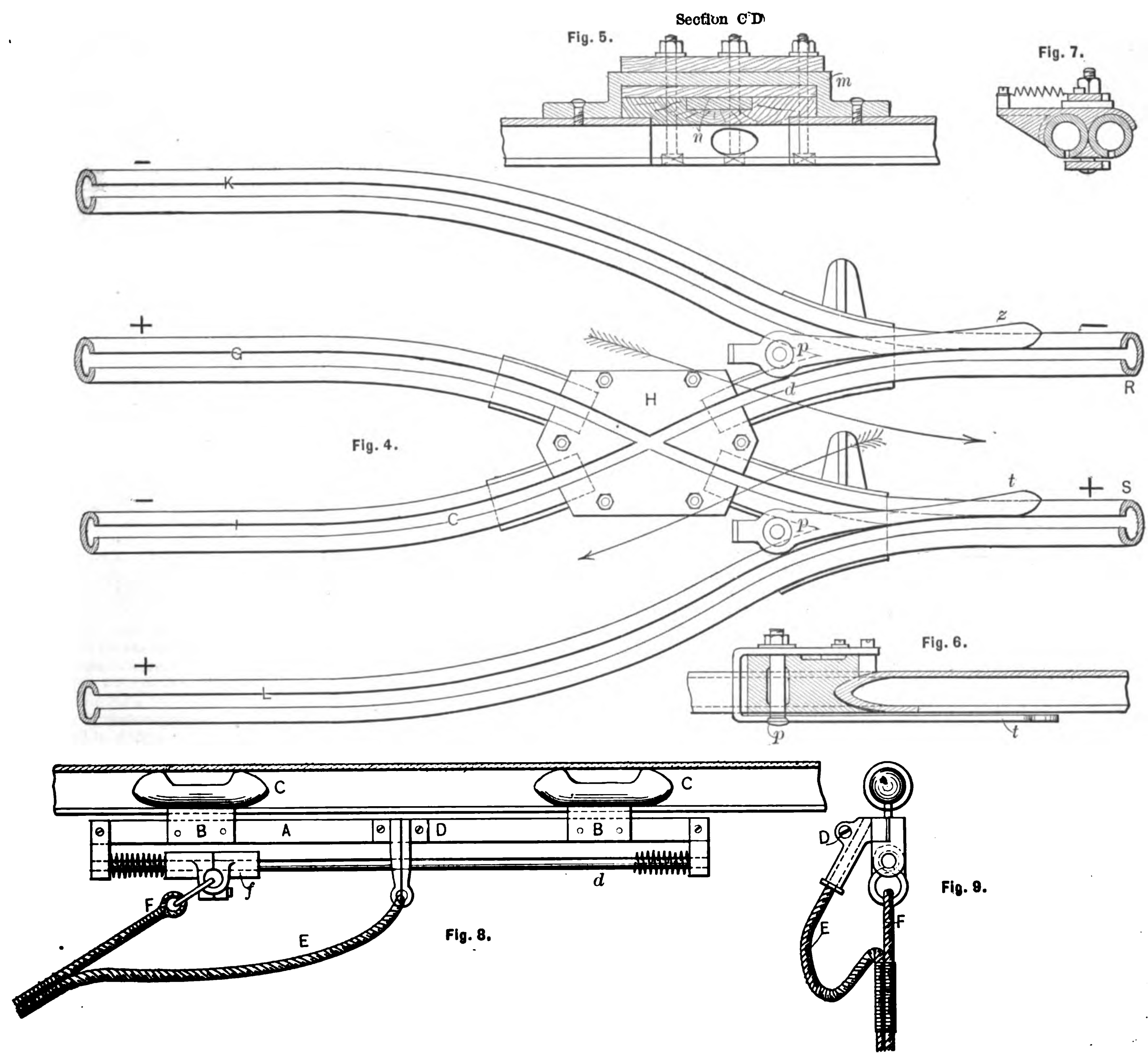
slide on this rod, and carry between them a ring, to which the rope F is fastened. Rope F takes off the conducting wire rope E the strain caused by the moving of the tramcar. The two spiral springs on the rod *d* act as buffers when the pull is in one or the other direction. This arrangement has given great satisfaction during the four years' working of the line, and fractures of the rope F and copper wire E, which during the first few months' working frequently occurred, happen now very seldom.

The central station for generating the electric current has been erected about the middle of the line in Oberrad. In the boiler-house three large cylindrical boilers are provided with inclined fire bars. The working steam pressure is 88 lbs. Under ordinary circumstances one boiler is sufficient to generate the necessary steam, but at times, when much traffic takes place, two boilers are in use; the third is a spare one. In the passage leading to the engine house two double-acting feeding pumps are put up, and close by is a deep water well.

The engine house contains two separate large horizontal engines, both fitted with automatic expansion gear. The larger is a twin engine, with modified Sulzer valve gear of 240 h. p., but only one cylinder is at present used. This engine was built by Mr. R. Küchen, in Bielefeld, and cost £1,400. The other engine, which has lately been erected, is a single cylinder one of 120 h. p., fitted with the Collinann automatic valve gear, the cut-off being capable of variation by the governor from *nil* to three-fourths of the stroke. Both engines are well suited for the heavy work, which consists of nearly eighteen hours' daily run, with only twenty minutes' stoppage during dinner time for lubricating purposes.

The countershaft is provided with couplings, and can be driven by either engine independently of each other; it has been arranged 20 inches above the floor, and makes about 300 revolutions.

There have been erected four vertical compound-wound Siemens dynamos, mounted on bed-plates with belt tightening gear, each capable of generating a current of seventy amperes and 300 volts — 21,000 watts, and absorbing about 40 indicated horse-power each. There is room for four more dynamos. On week days, under ordinary circumstances, when only four tramcars are running, two dynamos will suffice to do the work, one engine working with one-half power; but with eight electric trains on



Figs. 4, 5, 6, 7, 8, 9.—Details of Overhead Conductors at Crossing Points.

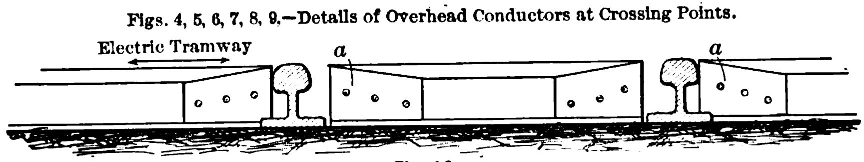


Fig. 10.

the road the engines indicated 164 h. p. There is also provided a repairing shop, with a track of rails leading into it for repairing the electric cars.

The rolling stock of this electric railway consists of 10 electric cars and four ordinary tramcars; the former weigh about four tons, carry 36 passengers, and cost £500 each; the latter weigh about two tons, and carry 24 passengers. The electric car is much stronger in its frame, which consists of channel iron, and carries under the floor the electric motor. The armature makes about 500 revolutions per minute, and has a diameter of 15 inches, and is about 19 inches long.

The method of gearing in this case consists of two pairs of spur wheels. The pinion on the motor shaft is of gun-metal, and has a diameter of six inches, 15 teeth and a width of two-and-a half inches. In this gears a steel wheel of 22 inch diameter with 55 teeth, mounted on a countershaft, which also carries a pinion of 12 inches diameter and 26 teeth. This drives a wheel of 24 inches diameter and 52 teeth, keyed on to the tramcar axle. The tramcar wheels are of 30 inches diameter. The total ratio of speed is, therefore, $\frac{55}{15} \times \frac{52}{26} = 7.3$, and with 500 revolutions of the motor the speed of the electric car will be $\frac{500}{7.3}$ $7.85 \times = 537$ feet per minute, or 6.1 mile per hour.

The traction force on tramways amounts, according to Mr. Reckenzaun's tests, to 25 pounds per ton rolling load on a level line, and the horse-power necessary to propel a train consisting of

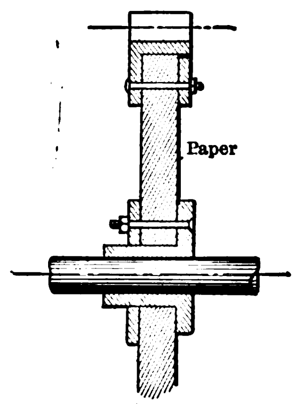


Fig. 11.

an electric car and an ordinary car, both with full load, with a speed of six miles an hour on a gradient of 1 to 32, will be found as follows :—

1 electric car, dead weight................	4	tons
1 ordinary car, dead weight...............	2	"
Passengers..................................	4.5	"
Total..................................	10.5	tons

$$\text{H.-P.} = \frac{W.\ K.\ S}{33000} + \frac{W.\ .2240\ S}{33000} \sin.\ \theta^*$$

$$\text{H.-P.} \quad \frac{10.6 \times 25 \times 537}{33000} + \frac{10.5 \times 2240 \times 537}{33000} \times \frac{1}{32}$$

$$\text{H.-P.} = 4.2 + 11.9 = 16.1.$$

If there are four such trains on the line, and the total efficiency taken to 40 per cent., the horse-power required to work the line would be $(16.1 \times 4)\ 1.6 = 103$ h. p.

There were several difficulties to overcome besides following the road in all its curves and gradients. For the electric tramway crosses once an ordinary horse tramway and several times the state railways, which are built on the same level. The rails of the former were cut and provided with chilled iron crossings as usual, but the latter were not allowed by the state railway authorities to be channelled for the passage of the wheels of the electric tramcars. It was therefore necessary to arrange on these rails wedge-shaped steel pieces, *a* (*see* figure 10), allowing the flange of the car-wheel to climb over the state rails as smoothly as possible. This, besides a tendency to derailment, had the great drawback that the steel tires of the wheels were worn in comparatively short time, and it was always necessary to drive very slowly over these railway tracks, or the inmates of the cars were subjected to very unpleasant joltings, as visitors will remember.

The gear-wheels at first used were of a somewhat elastic construction, consisting of a spider keyed to the shaft, having a toothed rim round it; the four projections of the spider pressed against india-rubber buffers inside the rim, and thus gave a certain amount of elasticity to the gear, with the intent to ease the starting. But now the cast steel rim of the wheel and the nave are connected by a disc of compressed paper (*see* figure 11), which construction has given good results. On each end of the tramcar are provided two levers, one for the brake, which is arranged as on ordinary tramcars, and one for starting the motor and regulating its speed. If two electric cars are coupled together, forming one train, the starting gears on both are mechanically connected, and the driver in the first car has perfect control over both motors. The brakes on both cars are now also mechanically connected. The cables for conveying the current enter the car through two tubes fastened on the roof of the car, and are brought under the floor to the brushes of the motor. Plugs are arranged in the roof above the driver's head, the drawing of which, in cases of emergency, interrupts the circuit, and consequently stops the motors.

The overhead conductors show scarcely any sign of wear, which may be due in part to the frequent cleaning and greasing of the tubes; the cast-iron pistons sliding in them last from five to six weeks, when they have to be renewed, the cost of which is very small. The greatest wear and tear are found in the gear-wheels. The metal pinion wears out in about six weeks; helical teeth have given better results. Heavy snow has given much trouble in the winter to this exposed line, and occasionally interrupted the traffic for a few hours. The trains run every twenty minutes from 6 A. M. till 11 P. M., and over one million passengers were conveyed during last year. On the whole the working of this line has been very satisfactory, and is greatly to the credit of Messrs. Siemens and Halske, who supplied the electrical plant.

ELECTRICAL STRESS IN DIELECTRICS.

At the meeting of the Society of Telegraph Engineers, London, held on the 22d inst., a paper on the above subject was read by Professor A. W. Rücker and Mr. C. V. Boys.

Professor Rücker, in introducing the subject, referred to the researches of Ker, Gordon, Quincke, and Röntgen on the stress in dielectrics placed between conductors at different potentials, and mentioned that Professor S P. Thompson had exhibited a lecture experiment to his classes, illustrating the stress in bisulphide of carbon. The authors did not profess to give any new results, but in view of the importance of a general recognition of the fact that electrical action takes place in the dielectric separating conductors they had devised some experiments which would exhibit these actions to an audience.

The first experiment shown was the introduction of a slab of paraffine between the plates of a charged condenser in connection with the two pairs of quadrants of an electrometer, showing the increased induction owing to the specific inductive capacity of paraffine being greater than air. That the effect was not due to a film of moisture on the surface of the paraffine acting as a conductor was shown by touching the paraffine, which did not alter the deflections of the electrometer; but when the paraffine was coated by tin plates, though the same deflection was produced in the first place, the needle flew back when this metallic casing was touched. Maxwell arrived at the conclusion that the stress in the medium was of the nature of a hydrostatic pressure perpendicular to the lines of force, combined with a longitudinal tension along the lines of force. A kind of crystalline structure should therefore be produced in the medium, so that we should expect its action on light to be similar to that of a crystal with its axis parallel to the lines of force. It was shown that when plane polarized light passing through a glass plate placed between two Nicol's prisms is extinguished by turning the second Nicol, the light is partially restored when the glass is subjected to stress. Some experiments due to Ker on electrical stress in bisulphide of carbon were then shown, with the modification of using long cylinders as conductors in the place of spheres, in order to increase the thickness of the medium, and magnify the effect sufficiently to render it visible when projected on a screen. A glass and wood cell, cemented with shellac, and containing two parallel cylinders immersed in bisulphide of carbon, was placed between two Nicols and traversed by a beam of light parallel to the axis of the cylinders. It was then shown that after extinction had been produced, the light passing through the annular space between the cylinders again became visible, when they were oppositely charged, by means of a Wimshurst machine, showing that the attraction was accompanied by stress in the intervening medium. Two cylinders, connected together, and placed between a pair of metallic plates, also in connection, were then charged, the pair of plates and the pair of cylinders forming the electrodes, and it was shown, as before, that the repulsion between the similarly charged cylinders was accompanied by a state of stress in the medium between them. The existence of stress was then shown in the case of a Franklin's pane, with bisulphide of carbon as the dielectric instead of glass. In a similar Franklin's pane, but containing windows in its lower half, the restoration of light was greater in the upper half, which would be expected on Maxwell's theory; while, if the effect was due to irregularities of action at the edges, there ought to be a greater restoration of the light

* Vide *The Electrician*, January 6th, 1888, page 209.

passing through the lower half. The phenomenon of Newton's rings was reproduced by means of a pair of plates, one of which was plane, while the opposed face of the other was a portion of a convex cylindrical surface, the colors being due to the varying stress in the bisulphide of carbon separating them, the stress, of course, being greatest where the distance separating the conductors was least. Some beautiful chromatic effects were also shown by means of Franklin's panes, with the aid of quartz and selenite plates.

CORRESPONDENCE.

NEW YORK AND VICINITY.

The City Press Castigates the Arc Lighting Companies.—Coroner's Inquest on the Death of Thomas Murray.—Mayor Hewitt as a Cantankerous Witness.—His Honor Withdraws from the Board of Electrical Control.—Screening the East River Bridge Lights.—Electrical Science in the Board of Aldermen; the Love of Boodle Still Prevalent.—Fire at the Edison Station on Liberty street and the 39th street Telephone Exchange.—Meeting of Subway Workmen.

THE daily press has devoted much space during the past month to an arraignment of the arc lighting companies for the dangerous condition of their wires throughout the city. It is worthy of note, however, as pointed out by Mr. Powers, of Troy, at the recent meeting of the American Institute of Electrical Engineers, that the practice of abandoning telegraph and telephone wires is really the most objectionable feature of the existing overhead systems. There is a vast number of private lines in the city, the owners of which as has been said of the patent office are "responsible for nothing, and responsible to nobody." If the use of copper line wire was compulsory this evil would be remedied at once, as the pirates of the housetops would see ample financial inducements for removing "dead" wires to the nearest junk shop. The death of Thomas Murray, the Brush company's lineman, was a case in which carelessness of the victim was combined with neglect of the corporation. It is not good practice to leave a "dead" loop in circuit, when a subscriber has been discontinued, as every surplus foot of wire, adds to the possibility of trouble, and even if permitted to remain it should be cut entirely clear of the main line. The inquest upon the body of Murray, conducted by Coroner Levy, has been of unusual interest by reason of the peculiar character of the testimony elicited. Foreman Siers, of the Brush company, posing as a lineman of great experience, considers the lines of that company as being in first-class condition. Mayor Hewitt, when called upon, said flatly that he knew nothing about the case. The jurors did not take kindly to his honor's manner of testifying or rather refusing to testify, and he is to be called before that body once more, when it is intimated he will be compelled to give satisfactory replies to the questions of the coroner, or possibly held for contempt like the ordinary citizen. It would have been an unique spectacle had his honor been placed in charge of Fatty Walsh, until he promised to be a good boy. The mayor's dramatic withdrawal from the Board of Electrical Control on May 10th under a display of oratorical fireworks by Commissioner Gibbens, was a choice morsel for the reporters. He was really harmless, but his sarcastic criticisms of his colleagues were decidedly unpleasant to gentlemen of such dignity as Commissioners Hess and Moss.

At the request of the lighthouse board, reports have been made by Major Heap and Lieutenant Millis as to the best remedy for alleviating the annoyance to pilots arising from the dazzling glare of the arc lamps on the East River bridge. Major Heap suggests the use of ground or colored glass globes as an experiment, and if these are not successful that screens should be used. Superintendent Martin, of the bridge, says it is proposed to apply reflectors to the lamps which will not only screen them but confine the light to the bridge, where it will be beneficial to the public.

The board of aldermen refused to concur in the report of its committee in favor of permitting the use of electric cars on the Fourth avenue line. The discussion in the board was a model of scientific misinformation. Alderman Dowling, confounding the harmless methods of a storage battery motor, with the "deadly wires" of the press, drew a heartrending picture of the dangers to which the innocent passengers would be subjected. "Suppose" said he "that the insulation was broken, or a wire and a nail, a piece of iron or a screw came in contact with it, and suppose a passenger with a steel nail in his boot heel should step on this. He would be killed!" The popular supposition appears to be that the allurements of boodle have not been altogether neutralized by the ventilation of aldermanic methods in the Sharp trial.

The branch station of the Edison company at 62 Liberty street was seriously damaged by fire on the morning of May 23d. This is a small auxiliary plant, used in connection with the Pearl street central station during the winter season, when the latter is sometimes overtaxed on dark days. It had been shut down for a week, and the fire is supposed to have originated from spontaneous combustion in a pile of greasy waste. The machinery was seriously damaged by both fire and water. The property was fully insured.

The night of the 23d, the 39th street exchange of the Metropolitan Telephone and Telegraph Co. was badly damaged by a fire which is thought to have originated from the current entering the switch-board from an arc lighting wire. The location of the supposed cross has not been determined. The prompt arrival of the insurance patrol and their effective protection of the switch-boards and other machinery with tarpaulins made the loss much less serious than was at first supposed. Telephonic communication was, of course, generally interrupted through the exchange, but a large force of men is actively engaged in repairs, and it is believed that within a week the service will be practically restored.

A meeting of the subway workmen has been held, at which some indignation was expressed because the work is not given out in larger portions. They are of the opinion that 2,000 instead of 800 men should be employed, and would be if permission was given to open the streets.

NEW YORK, May 30th, 1888.

PHILADELPHIA.

A Suggestive Address on Wasteful Engineering.—The Rapid Transit Electric Railroad Company to Test their Motors in Philadelphia Streets.—The Legality of the Penn Electric Light Company's Underground Franchise Questioned.—The Philadelphia Electrical Society; Its' Investigation of Protectors against Heavy Currents.

BEFORE the Franklin Institute recently, William Barnet Le Van read an interesting paper on the decline of engineering, illustrated by examples taken from local practice.

He said no profession is so little understood by the general public as engineering. A work requiring the expenditure of a large sum of money might be made one per cent. more profitable by the best than by the second best engineer. The gentleman went on to say that it is apparent that the first object in most engineering works is, that they be made to pay those who obtain the charters without any regard for the shareholders or the benefit to the public. Great works are extravagantly arranged, located, and operated. Economical power is wanted, and the secret of economy lies in adapting the highest practicable pressure of steam, thorough jacketing, the earliest cut-off at which the engine will run, and as perfect condensation of steam as possible after the steam has done its work.

The best engines are easily worth their cost. Mr. Le Van then devoted some time in referring to various enterprises recently established, among which were the Brush electric light plant and that of the Edison Lighting Co. He said the former might have been more cheaply located on the river. After making some interesting calculations as to the expense in such case, the gentleman made reference to the waste of steam in the city of Philadelphia, which he characterized as inconceivable. The earning power in dollars and cents of the waste steam power would feed and clothe all the poor in the city. Mr. Le Van closed with a glance at civil engineering, observing that, for the sake of economy, a road must be ran as straight as possible, as subsequent straightening and improvements would cost double.

Council's electrical committee, a few days ago took up an ordinance providing for a practical test of the Rapid Transit Electric Railroad Co.'s motor.

The bill provided that the consent of council shall be given to the use of Twenty-ninth street so far north of Norris street as it may be opened, for the purpose of demonstrating to councils the practicability of the operations of the electrical cars.

Mr. Crawford Spear, on behalf of the company, made a brief statement of its intentions, and claimed that this electrical system would largely do away with the demand for elevated railroads.

On Mr. Freeman's motion, the bill was amended so that the tracks shall be laid north of Diamond street in order to avoid the necessity of tearing up Twenty-ninth street, between Norris and Diamond.

A clause was added requiring that security in the sum of $10,000 shall be given in order to bind the company to restore the street to its original condition should the road be abandoned.

With these amendments it was agreed to report the bill favorably.

At a meeting of councils law committee the matter of the legality of the ordinance by which the Penn Electric Light Co., of New Jersey, was allowed to lay conduits in the streets all over the city, was brought up.

After a speech by Mr. Scott, in which he contended that the ordinance was unlawful, and that the laying of the conduits in the form of cheap board boxes was merely a cloak by which the streets were to be held in possession by the company, the whole subject was referred to a sub-committee, which was instructed to obtain an opinion from the city solicitor on the subject.

The rooms of the Philadelphia Electrical Society, at 1714 Chestnut, have been made very attractive for the electrical student. All sorts of apparatus and devices in the electrical line are always to be found there for testing and experimenting purposes. The society hold weekly meetings, and seem to be in a prosperous condition.

The frequent accidental crossing of the electric light with the telephone and other conductors, thereby causing dangerous fires in this city, has directed attention to the necessity of some device to protect the telephone and telegraph instruments, and the electrical society has been making tests to determine the very lowest possible dangerous current.

A few evenings since a trial test of protectors was made at the society rooms at which several automatic protectors were tried, but the current although dangerous, was too feeble to work them. Then came several which opened or broke the circuit. The result of the experiment showed particularly fine work on the part of the protector known as the "Plush," which is in general use by the Western Union company and at a number of the Bell telephone exchanges. It was demonstrated that any current which will do damage will cause the lever of the "Plush" protector to fall. The advantage of this instrument was shown by the fact that when an abnormal current caused the lever to fall, it was restored to its place by the hand. No stringing of any fine wire is necessary.

PHILADELPHIA, May 16, 1888.

BOSTON.

The Refusal of the Supreme Court to Rehear the Telephone Cases.—Mr. Thomas A. Watson's Prediction of the Influence of the Telephone in Politics.—A Bond Issued by the American Bell Telephone Co.—Statement of the New England Telephone Co.—The Illegal Conduit Order Passed over the Mayor's Veto.—The Conduit Question in the Legislature.—The Telephone Companies Continuing to Lay Wires Underground.—Competition of Police Signal Systems.—Electric Light Casualties.—An Edison Electric Light Plant for Charlestown.

BY the decision of the Supreme Court rendered on the 14th inst., refusing to reopen the telephone cases, the great controversies relating thereto would seem to be at an end. It has been a persistent and hard fight on the part of each contestant, and of the defenders of the Bell patents. In the year 1880, in conversation with the writer, Mr. Thos. A. Watson, who has been called the "assistant of Mr. Bell" in the development of the invention, remarked, in his enthusiasm regarding the future of the telephone, "that it was destined to create great commotions in the industrial and even in the political interests of this country." His idea being that the telephone interest would be so great, as to enter the domains of politics in the questions that would arise concerning its use and extension. Mr. Watson's remark has often been recalled since the *furor* created by the Pan electric cases. The part of the National Administration in those cases may become more and more a factor in the presidential campaign now upon us.

The American Bell Telephone Co. are to issue $2,000,000 seven per cent. bonds, each stockholder owning 50 shares to have the right to subscribe for a $1,000 bond; the bonds are to be redeemed in 10 years, and the company to have the right to call them in after two years from date of issue at $110 and accrued interest. The money obtained in this way is to be used in construction of ong-distance telephone lines.

The comparative earnings of the New England Telephone and Telegraph Co., from their report for 1887, are given thus:

	1887.	1886.	Increase.
Gross	$1,011,836.53	$919,109.64	$92,726.89
Expenses	727,184.92	659,695.89	67,489.03
Net	$284,651.61	$259,413.75	$25,237.86
Dividends	259,413.75	210,000.00	49,413.75
Balance	$25,237.86	$49,413.75	*$24,175.89
Total surplus Dec. 31.	$127,151.61	$101,913.75	$25,237.86

*Decrease.

The mayor's message, returning without his approval the order granting to Henry E. Cobb and others the exclusive right for 20 years to build conduits in certain streets, was taken up on motion of alderman Gove, at the meeting of the board of aldermen on the 7th inst., and without debate the board, by a vote of eight to four, passed the order, the objections of the mayor to the contrary notwithstanding. The vote was as follows:

Yeas—Aldermen Eddy, Gove, Kelley, McLaughlin, Murphy, Rogers, Short and N. G. Smith.

Nays—Aldermen Allen, Doherty, C. W. Smith and Wilson.

Mayor O'Brien instructed the superintendent of streets on the 8th inst., to issue no permits to Henry E. Cobb and others to dig up the streets for the purpose of building conduits. His honor says:

"In the first place, the company has got to file a bond that is satisfactory. If they begin to dig up the streets without a permit the police will arrest them, and that will get the matter before the courts. The police have standing orders to arrest anyone who digs up the streets without a permit. My instructions to the superintendent of streets are final; he has no option in the matter."

The common council are not in accord with the other branch of the city government, concerning their action in the conduit matter, and can only "resolve," as they did on the evening of the 19th ult., as follows:

Resolved, That the board of aldermen as surveyors of highways possess a dangerous power, which should be curtailed or limited by legislation.

Resolved, That their recent action on the conduit orders, in granting extraordinary privileges to a private corporation for 20 years, in secret session, was the most outrageous legislation ever passed by the board, and calls for an immediate and decided change in the laws to protect our citizens and taxpayers; it is therefore

Resolved, That in the opinion of the common council, the board of aldermen should either be abolished or the common council given a concurrent vote on all matters in relation to streets, and that this council petition the legislature, now in session, for such a change in the laws as will prevent such outrageous legislation in the future.

The resolves were declared passed; but upon a yea and nay vote being called for, it was found that they were lost by a vote of 30 nays to 11 yeas.

The order requesting the committee on judiciary to ask the corporation counsel to define the relative powers of both branches of the city council in regard to the streets of this city, both surface and underground, and uses of the streets for any purpose, was passed in concurrence with the board of aldermen.

At the State House, on the 20th ult., the committee on mercantile affairs continued the hearing on the matter of conduits for electrical wires. Professor Cross, of the Institute of Technology, was present to explain, at the request of the telephone companies, the difficulty of placing wires as closely together as would be necessary in underground conduits. A room was fitted up with wires and other apparatus to enable him to demonstrate it. He paid most attention to the effects of induction between wires, showing that when a coil through which a telegraphic current is passing is brought within a distance even of three feet from another coil connected with a telephone receiver, the telegraph current causes distinct sounds to be heard, so that a message could be read at the telephone. With another coil through which was passing a dynamo current about sufficient to produce an ordinary incandescent light, a roar was produced by induction across three feet of air, that one member of the committee compared to a western cyclone.

The effect of induction from one telephone circuit upon another was also shown, the voice of one person talking through an ordinary transmitter being distinctly heard on another circuit running parallel, but not touching it. He said that induction could be prevented by encasing the wires in lead tubes, but that this would give rise to another disturbing effect—that of retardation—since the presence of the mass of metal would act as a drag upon the current passing through the wires. Without going into technicalities, he illustrated the difficulty of placing wires, especially those carrying different kinds of currents, near each other. He said that, however, by a system of twisting two wires together, using one to complete the circuit, instead of the present system of single line circuit, using the ground to complete the circuit, the effect of induction could be reduced to a minimum, at, of course, a much increased cost for the change of system.

In answer to questions by Samuel L. Powers, counsel for the petitioners, he said that the only practical difficulty in the way of placing telephone and telegraph wires underground in the same conduit was the matter of cost. But he was positive that arc light currents could not be placed in the same conduit under any circumstances. If they must go underground it must be by separate conduits. Not only would the induction interfere with the successful working of the other wires, but there would be increased danger to the workmen upon the other wires.

H. N. Shepard appeared in remonstrance for the New England Bell Telephone Co. He began by reviewing the history of the matter of conduits in Boston, saying that the present effort to secure the sole franchise was made by the American Conduit and Construction Co., of which the principal stockholders were Michael Meehan, formerly superintendent of streets, James J. Colman and Frank E. Magullion, liquor dealers. This company owned a patent for making carbonized stone, and was organized with a nominal capital of $1,000,000, which they certified had been paid in as required by law; but a little investigation showed that but $600 in cash had been paid, the balance of $999,400 consisting of "patents and franchises." He then showed that the telephone company was gradually putting all its wires underground in this city. It already has 4½ miles of conduits in the streets of Boston, in which there are 785 miles of wire, with room for 6,300 miles more. About $75,000 has already been spent for this, and $50,000 more will be expended in another year. The method used does not disturb the streets for more than three days in any case, and man-holes are provided at frequent intervals for the purpose of inspection, so that the surface of the streets is not again disturbed. He criticised the action of the board of aldermen in granting the exclusive franchise which they did, and disputed the statement before made by Mr. Powers, that exclusive franchises had been given in other cities for the building of conduits. To support this he read letters from the Brooklyn electric subway commission and similar

bodies in other cities, showing that in no large city is there a conduit holding both arc light and telephone wires, and that in no city has there been granted an exclusive franchise as contemplated here.

Thomas D. Lockwood, an electrician of the telephone company, said that his 20 years of practical experience had led him to the same conclusions as those reached by Professor Cross from a scientific point of view, though he might differ from him in a few details. He showed the difference in the different currents, by stating that taking the strength of a telephone current at one, a telegraph current would be 212, an arc light current 5,308. He argued at length to show that the telephone company was doing its best to put its lines underground, but wanted to do it in its own way, as it is a new subject, and the way must be felt by experiment. He stated that no new wires were being strung overhead in Boston by the company, except in a very few cases.

Ex-councilman H. L. Harding appeared for the Citizen's Association, and stated that the association wished to present a bill providing for placing the wires underground, but in a different way from that proposed.

The hearing was adjourned until the 20th, when D. A. Harrington, engineer of the New England Telephone and Telegraph Co., described the system of conduits now in operation by that company.

J. W. Bennett, of the Erie Telephone & Telegraph Co., stated that in the cities with which he was acquainted there was no system of conduits that worked satisfactorily.

Joseph W. Learish, engineer in the employ of the Western Union, corroborated the statements of Professor Cross relative to induction, and the testimony in reference to the interference of wires.

The committee were given until the 15th inst. to make a report —on which date the committee on mercantile affairs reported a bill for placing electric wires underground. Senators Clark, of Hampshire, Cook, of Essex, and Stevens, of Norfolk and Representative Gill, of Worcester, dissent. The bill gives permission to local authorities to construct general systems of subway conduits through which to conduct all classes of electric wires and cables, and may provide on contract for their construction and maintenance, but no exclusive rights are to be granted. When enough conduit has been built to warrant putting the overhead wires underground, the local authorities may order the change to be made, provided that the wires and cables can be operated in the conduits without material injury to the interests of the persons or corporations operating them, but in no case shall electric light and power wires be put with other electric wires in any conduits without the written assent of all the persons and corporations operating the telegraph and telephone wires in the same conduits. Authority is given to compel the removal of the poles now erected. The local authorities may prescribe the terms on which the conduits shall be used, and may fix the tolls. Refusal to put the wires underground, upon order, is punishable by $500 fine for every offence. Existing rights in conduits already laid are not to be affected.

Meantime the telephone companies are actively engaged in putting down conduits in the streets in which they have obtained the right and privilege so to do, and if not disturbed, will soon have down all they will require for some years to come.

The police signal systems are having a sharp contest in the city for supremacy; the Gamewell, represented by Joseph W. Stover, and the Municipal, represented by John C. Wilson. The board of police, on the 3d inst., opened the bids for the contract for building the signal system on divisions 3, 4, 9 and 15. There were two bids, from the Gamewell system, represented by its president, Joseph W. Stover, and the Municipal system, represented by general manager John C. Wilson. Mr. Wilson's bid was the lowest, and he was awarded the contract. After some further debate the amendment was rejected—7 to 21—and the bill advanced one stage.

New England and the east have experienced the epidemic, now quite general, of trouble with electric light wires. Fire in Fall River, on the evening of the 25th ult., destroyed the plant of the electric station of the Edison company. The company had 4,200 lights on its lines. Guests at the Harvard ball, the social event of the season, were left with a few gas jets and a lamp or two. In Halifax, on the 1st inst., another electric light patrol man, named Geo. Crocker, was killed on the same spot as was Welber on Sunday night, under exactly the same circumstances. He went up a post, threw one of his legs over a cross-piece, when it must have come in contact with the wire. He then clutched the wire with his hands and was killed instantly. Crocker had had considerable experience in the business and it was thought knew all about it.

The electric lighting system is to be introduced into the Charlestown Navy Yard, and the dynamos, wires, lamps and other appurtenances to be used, will be bought outright by the government. The shops and streets will be illuminated with arc lamps, and the offices and residences by the Edison incandescent system. It is expected that the system will be in full running order before the next winter.

BOSTON, May 16th, 1888.

CHICAGO.

The Alternating Current Discussion at the Chicago Electric Club.—Mr. Elmer A. Sperry on Alternate Current Motors..—Club Notes.—A Gas Explosion.—Difficulty of Running Electric Light Circuits in Chicago.—The Town of Pullman to have an Electric Railway.—The Electric Railway at St. Paul Opened May 10.—Other Railway Notes.—Growth of Electric Motor Business.—The Chicago Telephone Company Hampered by the City Council.—The New Telephone Building.—The Western Gas Association.—Electric Light Men Excluded from a Benevolent Assurance Society.—Electric Light Notes.—The New Thomson-Houston Building.—Reducing Ores by Electricity; Mr. H. B. Slater's Method in Use in a Silver Mine at Leadville.—Professor Elisha Gray's Lectures at the Northwestern University.—Long-lived Incandescent Lamps.—Intense Competition in Electrical Business.—The Western Electric Co. Preparing 200 Arc Lamps for their New York Factory.—The Cushman Telephone Co. about to Commence Operations in Chicago, and in Logansport, Ind.

THE greatest interest is manifested in the series of discussions now before the Chicago Electric Club, on the Continuous Current *vs.* the Alternating Current. The fifth paper was read by George Cutter, of the Thomson-Houston company. The title of the paper the "Continuous Current Limited *vs.* the Alternating Current Unlimited," indicates very nearly the spirit in which Mr. Cutter treated the subject. He found little or no place for the continuous current in the economy of electrical distribution. He entered the lists according to his own declaration as a partisan of a pronounced type and he proved himself a strong champion. He thought the continuous current had served an excellent purpose as a pioneer, but for the future the alternating system was alone desirable and economical. Mr. Leonard, of the Edison company, championed his system warmly in the discussion which followed. Whatever may be said of the merits of the question Mr. Leonard may well feel flattered by the course which the series of papers has followed. Since the reading of the first paper by him all those who have entered the discussion have sought to weaken or support his position. All the arguments have had reference to statements which he made so positively in his treatment of the subject. At the meeting, May 21st, Mr. Elmer A. Sperry read an interesting paper on alternating current motors. Mr. Sperry is a thorough believer in the alternating current, and his topic called forth an interesting discussion. George H. Bliss will present a paper in advocacy of the continuous current system at the first meeting in June. The Electric Club proposes to adopt means for increasing its membership. It is hoped to increase the number of members from 120 to 150 at least. The improvements which are now being made in the rooms will tend to make it more popular as a society, and there is little doubt that the roll of members will soon reach the desired number.

In the latter part of last month an explosion occurred in the basement of the building occupied by the Bell Clothing Co. on State street. The employés of the Arc Light & Power Co. were driving a tube intended for arc light wires under the sidewalk. A gas pipe was struck, the gas which collected in the cellar was ignited by a gas jet. The damage to the windows and stock amounted to several thousand dollars. The explosion serves to illustrate the difficulties which are met with by electric light companies in Chicago. They are not allowed to string wires overhead, and permits for digging up the street are not dealt out with a lavish hand. They frequently are obliged to resort to forcing a tube under a flag walk as in the case mentioned. This is the first accident of the kind, however, which has occurred from this cause in the city. It is understood that the electric light company settled with the clothing house for the damages within two hours after the explosion.

There have been a number of explosions within the last few weeks in the underground conduits. Man-hole covers have been blown off perhaps in a dozen instances. The "terrific force of the explosions," referred to in the daily press, does not raise the man-hole covers over two or three feet from the ground though the papers speak of several miraculous escapes. The city electrician, Professor Barrett explains the explosions in this way: "The gas pipes leak horribly. We must do one or two things; we must insist on air tight conduits or the gas company must cork its pipes so they will not leak and the gas collect in the conduits. Pipes everywhere are badly jointed, and when the ground is thawing everything is saturated with gas. This escaping gas is so plenty that it often must be pumped out before an employé can enter a man-hole to work. We have to open up a system of man-holes every week or two to get ventilated. We have been studying a system of ventilation but can't get a draught through the conduits. There are seven conduits, and I believe they should be under one management. I think the city would be benefited by assuming the construction of a general conduit and by compelling the corporations to use it." It would seem from this statement that the gas companies alone are responsible for the explosions which unquestionably create no little uneasiness.

The Pullman Palace Car Co. is to build an electric road in its substantial town of Pullman. The road will be five miles in length. The overhead system will be employed, and the cars which, of course, will be turned out at the Pullman works will be of ele-

gant design. Mr. Charles Pullman said to the ELECTRICAL ENGINEER representative that it was proposed to push the road rapidly to completion. An electric road in St. Paul was opened May 10th, with appropriate ceremonies. Representatives from Minneapolis were present to extend congratulations. Milwaukee will soon have an electric road six miles in length. There is considerable interest manifested publicly in Chicago in the electric motor. The working of the north side cable road has by no means been satisfactory; and following the rule that misfortunes never come singly, the system has usually broken down at the time when most persons desired to reach the city or wished to return home. This fact has given rise to a general desire among street car men to experiment with other modes of street car propulsion. Thus far the talk of electric street roads in the city amounts to very little; but that there is a general interest in electric roads is true beyond doubt, and the investigation which has thus been encouraged may soon yield something tangible.

There is an increased demand for small motors. The Sprague company has recently installed two 10 h. p. motors and one of half that capacity in the Phœnix building. They are employed to drive three ventilating fans. They run without sparking and are giving perfect satisfaction.

The Chicago Telephone Co. has been in anything but a pleasant situation. The company asked permission of the city council to move its wires so as to accommodate the subscribers who had moved. The city fathers, who oppose the telephone corporation almost to a man, refused to consider the request. Mayor Roche came to the rescue of the company. He gave into the hands of city employés the task of removing the wires, and the cost of the work will be charged to the company. The telephone company claims to have the finest building used as an exchange in the world. It is an elegant structure and all its appointments are of the latest design. The 2,200 wires previously running into the branch exchanges were transferred to headquarters May 12th. The work had been so well planned that connection was not interfered with for over 10 minutes on any wire. Naturally the transfer to the new quarters caused confusion for a few days, but the exchange is now in excellent running order.

The Western Gas Association met in Chicago for three days, beginning May 9th. The only electrical paper was that presented by C. M. Keller, of Columbus, O., "On the Cost of Arc Lights." His company has two 50-light machines. For an all night light the expense was, he said, 20½ cents per night; for a 11 o'clock light the cost was 17½ cents. The members discussed the paper with interest, and it seemed to be the impression of the progressive majority that gas companies in order to hold their own must put in electric light plants.

Those who are interested in electric lighting are somewhat surprised to learn that the Royal League, a secret benevolent insurance company, had a rule declaring all persons who handled electric light apparatus in any way ineligible to membership. As this applies to engineers, electricians and many others, there is considerable dissatisfaction expressed, as it is feared that this sweeping provision may be adopted by other insurance organizations. They rightly consider their occupation as one which cannot be classed as hazardous, and they hold that if a rule is adopted in this regard it should be discriminating, and exclude only those whose work in connection with the electric light is actually attended by risk.

The contract for lighting the Mercantile Library Association building of St. Louis, has been awarded to the Excelsior Electric Light Co., F. W. Horne, western agent, Chicago. The contract calls for 100 arc lights.

In the new building of the Thomson-Houston company, an exhibition plant is to be fitted up showing all the apparatus sold by the company. Dynamos, feeding arc and incandescent lights, and electric motors will be in operation.

H. B. Slater, of Detroit, was recently in Chicago. He spoke of a method he had invented for reducing refractory ores by electricity. The process is said to be employed with success in the iron silver mine at Leadville.

Professor Elisha Gray is delivering a series of non-technical lectures on electricity before the students of the Northwestern University at Evanston. He gives a large number of experiments, in which he is always particularly successful. It will be several months before his telautograph is on the market.

The engineer of the Union League in Chicago, says that of the 1,000 lamps in the club house, between 200 and 300 have had a life of 4,300 hours.

The managers of electrical companies are not complaining of the amount of business which they find, but they do find fault with competition. They say that the intense rivalry is extracting every cent of profit, and that when a company enters into a struggle for a contract its officers must be prepared to install the plant for love and honor.

Two hundred arc lamps, to be used in the factory of the Western Electric Co. in New York, are being manufactured at the company's factory in Chicago.

The Cushman Telephone Co. will commence the first part of next month the work of soliciting subscribers for its Chicago exchange. The Logansport, Ind., exchange will be in operation June 15th.

CHICAGO, May 25, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, *11 Wall street, New York city.*

WELDING RAILS BY ELECTRICITY.

[93].—My attention has been called to a notice in the May number of your journal, under the caption "Welding Rails by Electricity," some of the statements of which convince me that the author is either totally unacquainted with the subject or has not considered some of its most important details.

The invention referred to in the notice consists in welding the ends of steel rails of ordinary length together, so as to form continuous tracks of one thousand feet of more in length, the energy employed to generate the heat being electrical. It also further consists in providing expansion and contraction joints at the ends of these long lengths to compensate for the varying effects of constantly changing temperatures.

There are several difficulties in the way of such a scheme that seem to me to render it impracticable. First, as is perfectly well known by any one who is conversant with the tempering properties of steel, the joints and adjacent parts of the rail could not be tempered equally with the other parts of the track, on account of the wide gap between the temperatures at which steel will chill or temper and anneal respectively. There would thus remain a soft or annealed portion of metal on each side of the joint, which could not be avoided except by heating and retempering the whole track.

Secondly, as a rail of steel one thousand feet long would contract about one inch and one-half for every ten degrees of drop in temperature, and as the range of temperature from maximum to minimum may be about 140 degrees Fahr. in this latitude, joints would have to be provided at every thousand feet which would allow a contraction of considerably over one foot. Nor is this all, for some means for facilitating the motion of the track due to expansion and contraction would have to be provided, or ruptures in the metal would occur; and it is extremely doubtful whether the tendency of such a rupture to buckle could ever be overcome by any mechanical arrangement. For instance, on a down grade every expansion would tend to force the track a certain length down, while the subsequent contraction would not be strong enough to raise the track to its former position.

There are other difficulties which suggest themselves to those familiar with the subject, such as the inconvenience of repairing worn portions of a track, etc., which render the project at present impracticable. It is hardly necessary to say that it would be practically impossible to make a welded joint in steel rails of several square inches area of section in less than "half a minute." It seems to me that the scheme here proposed is of the same impracticable nature as the recently proposed schemes for heating railway cars by electricity, in which the power for heating is derived from the propulsive power of the train—schemes which the present state of electrical science does not warrant us in saying that they will ever be put into operation with success,

Very truly yours, OTIS K. STUART.

POINTERS.

.... THE best individual telephone signal is an individual line. —*Thomas D Lockwood.*

.... THE tendency of science is to minimize natural advantages.—*Professor Ryan.*

.... THE telephone has a field of usefulness entirely separate and distinct from that occupied by the telegraph......If the long-distance telephone competes with anything it is with the railroad.—*E. J. Hall, Jr.*

.... IF the use of platinum was carried all the way through in switch-boards and bell connections, it would save a vast deal of money in inspection and give a vast deal of comfort and satisfaction in service.—*R. M. Bailey.*

.... I HAVE kept an accurate record of the current that went into my secondary battery, and the mean of the current that came out of it, during the last twelve months, and I have certainly got an efficiency out of the cells of 80 per cent.—*William H. Preece.*

... MECHANICAL engineers seem to look upon electricity as though it were some formidable rival. I wish they would regard it purely as a means of transmitting force from place to place. The manufacture of the dynamo and motor is purely a mechanical undertaking.—*Magnus Volk.*

ELECTRICAL NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

ANNUAL MEETING.

THE annual meeting for election of officers and other business, was held Tuesday Evening May 15, at the house of the American Society of Civil Engineers, New York. The President, T. Commerford Martin, calling the meeting to order said :—

It is with much pleasure, fellow members of the Institute, that I greet you on the evening which closes our fourth year. The year which we have just gone through, has seen, I think we may say, a noteworthy increase in the membership, the influence and the reputation of the Institute. We have, I believe, more than doubled our membership. We have had a corresponding increase in our funds, and owing to the larger resources at command, we have been enabled to give greater attention to the editing and publication of our transactions, and have been able to give them a standing which I believe is equal to that of the transactions of any similar scientific society.

The papers which have been brought before us during the past year cover a wide range of subjects, all of which fall mainly within our sphere of consideration. They are, "The Electric Lighting of Passenger Trains," by Mr. G. W. Blodgett; "The Coulomb Meter," by Professor George Forbes; "Electric Street Cars," by Anthony Reckenzaun; "Improvements in Apparatus for Ocean Cabling," by Charles Cuttriss; "Phenomena of Retardation in the Induction Coil," by William Stanley, Jr.; "The Revision of the Patent Laws," by Arthur Steuart; "Electric Energy from Carbon without Heat," by Willard E. Case; "Alternating Current Motors," by Dr. Louis Duncan, and "The Maximum Efficiency of Incandescent Lamps," by Mr. John W. Howell.

The papers were all of them, it may be said, of a high order of merit, and have done much to secure for the Institute the reputation which it now enjoys.

The first business in order this evening is the reception of reports from the officers of the Institute. We shall be glad I think to have first the report of the secretary and then take that of the treasurer, and the reports of the various permanent committees. At this time I think it will be well if I appoint a nominating committee to take in hand the matter of the nomination of officers for the ensuing year. Upon that committee I, therefore, nominate Mr. S. S. Wheeler, Mr. C. A. Terry and Mr. C. O. Mailloux. I will now ask the secretary to give us his report.

SECRETARY'S REPORT.

With the close of the fourth year of the existence of the Institute, your secretary takes pleasure in announcing that the work for which it was organized has been still more actively entered upon since the last annual meeting, and with exceedingly gratifying results. Believing that its past record was of sufficient importance and interest to warrant more general support from all who were interested in electrical science, it was deemed proper that efforts should be made to enlist the aid of all who appreciated the value of such an organization. This policy has been beneficial in various ways. It has made known the existence of the Institute, and gained for it a world-wide reputation. It has enlisted the support of new adherents, and stimulated the attachment of those who were previously associated with it. The additional revenue thus derived has enabled the council to carry out various plans for the general good, and increased the value of membership to distant as well as local friends.

The plan of holding more frequent meetings, undertaken last year, has been continued more systematically, and all have been well attended. The value of the papers presented, and the discussions which followed, are familiar to all by reason of their monthly publication and distribution. The transactions of the Institute have also been very generally printed by electrical journals at home and abroad. In order to add to the value of the Institute's publications, a classified index was begun in December of all articles of importance on electricity, appearing in technical journals, published in the English language. This index is appended every month to the issue of the Transactions. Some idea of its scope and of the work involved may be formed when it is stated that the index during its first six months of compilation has included under the various heads upwards of 2,500 distinct articles, for which have been given nearly 4,000 references, accompanied by over 500 explanatory and critical notes. The immediate appreciation of this work on every hand is a sufficient warrant and reward for its execution. Such an index, if existing to-day, of early periodical literature on electricity would be simply invaluable, as those who have occasion to make searches or are investigating in any branch can testify; and the secretary believes that by assuming the task at this time, the Institute will be found in a very few years to have done a work of inestimable importance. It is now proposed to extend the index so as to include all electrical books as they appear. The bibliography of electricity will then be rendered complete.

The Institute has doubled its numerical strength since the last annual meeting, besides reclaiming a good percentage of original members who had become lukewarm in their support. The increased revenue has been devoted to such purposes as would result in satisfying every member that he was receiving a fair equivalent for his share of the amount expended.

The project of providing permanent quarters, which has been referred to in three previous annual reports, has been given careful consideration during the past year by the council and its committee, as well as by the officers individually. Although greater progress might have been made, at the risk of abandoning the more important work of the Institute, it was deemed wise to continue for the present upon the line of policy which is now being pursued. The business affairs of the Institute and its accumulating literature made it necessary, however, that office quarters should be secured, and a suitable room has been leased and furnished for this purpose in Temple Court, No. 5 Beekman street.

The cordial relations which have existed since its organization between the Institute and the American Society of Civil Engineers still continue, and the meetings of the Institute will be held at the house of the latter, by courtesy of the board of managers, during the coming year, at the discretion of council.

There have been 182 associate members elected during the past year, of whom 166 have qualified by paying their entrance fees and annual dues. Four have resigned, one has died, one has been dropped from the roll, and one placed upon the suspended list. The total number of members and associates is 322, of whom 267 have paid up in full to date, seven are in arrears for the present year, twelve for two years, and thirty-six for three years. There has been an improvement in the delinquent list, by the collection of $387.50 during the year, but many of those who remain upon it have lost all interest in the work of the Institute. Others have met with financial difficulties which may yet be overcome.

The secretary takes pleasure in acknowledging the receipt of the following gifts from friends of the Institute:

From Mr. Edward P. Thompson, a carpet for the office of the Institute.

From Mr. T. C. Martin, $25 cash toward furnishing the same.

From Mr. Charles Colné, a set of Patent Office Reports.

From the Consolidated Telegraph and Electrical Subway Company, a bound volume of photographic views of the subways as constructed in New York city.

From Mr. Emile Berliner, a working model of his "Molecularium."

From Mr. Wm. H. Sawyer, files of the London *Electrician*, London *Electrical Review*, and New York ELECTRICIAN and ELECTRICAL ENGINEER.

Respectfully submitted,

RALPH W. POPE, *Secretary*.

NEW YORK, May 15, 1888.

The secretary's report was accepted and ordered on file.

The secretary then read the treasurer's report as follows:

TREASURER'S REPORT.

George M. Phelps, Jr., in Account with American Institute of Electrical Engineers.

Dr.

Receipts from May 21, 1887 to May 15, 1888, as per remittances from secretary		$3,871.02

Cr.

Payments from May 21, 1887 to May 15, 1888, on warrants from secretary (Nos. 1 to 63)	$3,468.58	
Balance to new account.................... ...	402.44	3,871.02
Balance on hand May 15, 1888..................		$402.44

NOTE.—The actual receipts and payments are each $100 less than above figures, that sum having been advanced for a contingent expense which proved not required when the amount was refunded.

Building Fund.

Amount paid on subscriptions and now in treas urer's hands..........................	$450.00

GEO. M. PHELPS, JR., *Treasurer*.

The treasurer's report as read was accepted and ordered on file.

At the suggestion of Mr. Phelps that an auditing committee examine the treasurer's report and vouchers, the President appointed Mr. G. A. Hamilton and Mr. F. W. Jones as such committee.

Capt. Michaelis—reporting for the wire gauge committee, said:—The committee have been rather inactive. I apologize to the Institute, but for various reasons nothing has been done lately in the matter.

After a brief consideration of the subject, the wire gauge committee was, on motion, discharged—the general view seeming to be that it would not be advisable to undertake any further action.

The report of the committee on permanent quarters, was given orally by Mr. Phelps, chairman, as follows:—

The portion of the secretary's report relating to the quarters of

the Institute may fairly be considered as the report of the committee. It states that the arrangement reported has been approved by the council, and the committee. There has been no material change in the project of raising a fund within the last few months. The state of the matter was published in all the journals. There was a subscription amounting to about $5,000, and of which, as the treasurer's report shows, exactly $450 has been collected. The committee did not prosecute to any great extent the solicitation of donations outside of the Institute, and the sum reached in the subscription list seemed to be pretty nearly the limit to be expected within the membership. But for various reasons the project of getting a house for ourselves during the past year has turned out to be impracticable, and the committee have joined with the council and the officers in recommending the hiring of the room in Temple Court, which will serve the secretary for his regular duties, and afford a convenient reading room, and also space enough for council meetings, which can be held conveniently down-town. The committee prepared no written report, relying upon the secretary's statement on the subject in his report.

The report of the committee on permanent quarters was accepted.

The President—There being no further committees to report, we shall be glad to hear from the nominating committee. While the nominating committee is coming, however, I would call attention to the fact that the vacancies which occur to night and which are to be filled are in the presidency, in the vice-presidencies of Dr. Green, Professor Elihu Thomson and Mr. George C. Maynard, and in the managerships of Mr. Charles L. Buckingham, Mr. David Brooks and Mr. E. P. Thompson. In the case of vice-president Elihu Thomson, and in that of Mr. E. P. Thompson, who were elected by the council to fill unexpired terms, I may say that both those gentlemen are eligible to reelection to like places.

Pending the arrival of the nominating committee, I would like to call your attention to the programme which we have before us for to-morrow. It is one of a very interesting character, and I have no doubt that the attendance will be large, and that the discussions will be interesting and valuable.

We have received the following courteous invitation addressed to the secretary:

RALPH W. POPE, ESQ.

Dear Sir:—On behalf of the Electric Club, I take pleasure in extending the courtesies of the Club House, 17 E. 22d street to the members of your association during the present week. As a matter of special interest, the Edison improved phonograph can now be seen and tested in the parlors of the club. Visitors from your association will kindly mention this invitation to the clerk of the club, and they will be promptly admitted at any time between 8 A. M. and 12 o'clock midnight.

Very respectfully yours,

CHARLES W. PRICE, *Secretary*.

I have no doubt that such of us as are not members of the club will be very happy to accept the invitation.

Mr. Phelps—In view of so courteous an invitation, I think it would be proper to accept it by vote and to extend the thanks of the Institute. I therefore move that the invitation be gratefully accepted.

The motion was seconded by Mr. Wetzler, and voted unanimously.

Mr. G. M. Phelps, Jr.—I hope that all the members who have not made themselves at home at the club will do so. They are quite sure to find it pleasurable in many ways.

The nominating committee presented its report.

Mr. S. S. Wheeler, chairman, said:—In presenting these nominations on behalf of the committee, it seems to be a good opportunity to call attention to the feeling that prevails in the Institute in regard to getting the services of men who will give some of their time and energies to the work, and I would say that all these men have been selected in reference to that. The nominations are:

For president, Edward Weston.

For vice-presidents, Elihu Thomson, F. R. Upton and T. C. Martin.

For managers, Charles Cuttriss, George B. Prescott, Jr., William Maver, Jr. and T. D. Lockwood.

For secretary, R. W. Pope.

For treasurer, G. M. Phelps, Jr.

Capt. Michaelis—As I have heard no other nominations made, I move that the secretary be authorized to cast a ballot for the individuals named by the committee as the vote or ballot of the society.

The motion was carried unanimously.

The President—Will Mr. Vansize and Mr. Thompson please act as tellers to receive the ballots?

Mr. Vansize—Your committee, to whom was assigned the duty of scrutinizing the ballot for officers for the ensuing year, have to report that the ballot was cast in accordance with the motion passed, and herewith hand you the result of the ballot.

The President then announced that the persons named by the nominating committee for the respective offices were elected.

The President—Is there no other business to be brought before us this evening?

Capt. O. E. Michaelis—At the last annual meeting the subject of certain amendments to the constitution was considered, and the matter was referred to the council. As under the constitutional provision such amendments can only be considered at the annual meeting, or at a meeting called for the purpose, I would like to inquire whether it might not be advisable in the course of this meeting, either to-night or to-morrow, that this subject, a very important one certainly, be brought forward for consideration.

The President—Since no action has been taken I presume a new motion would have the effect of vitalizing that subject.

Capt. Michaelis—I move, then, that the council be requested to make such reports on the amendments to the constitution as they deem advisable to the meeting to-morrow.

The motion was seconded.

Mr. Phelps—If you will permit me, Mr. Chairman, I believe that as a matter of fact the council have given no attention to preparing amendments to the constitution. I suppose it would be quite impracticable between now and any session we may have to-morrow to put in proper shape any general revision of the constitution or rules, and even any particular revision. Such an attempt would necessarily occupy a great deal of time, and to-morrow, when we have a great many papers, there will scarcely be time to act upon the subject with due deliberation.

Mr. Mailloux—There is one matter particularly which I think should receive our attention in revising the rules, and that is the manner of conducting elections. I do not approve of our present method of electing officers. The annual meetings are never fully attended, and under our present procedure it is impossible for us to get anything like an expression of general sentiment among the members. It seems very strange indeed that some forty or fifty members should have to do the electing for over three hundred, and I think we ought to adopt some measures similar to those which are followed in other engineering societies. The present plan brings the selection to a very narrow limit, and may engender unpleasant feeling some time. If a more general participation in nominations could be secured by a change of method it would be more satisfactory.

The President—It is not the desire of the chair to participate at any length in a discussion which is certainly likely to be valuable, but I think it my duty to point out that Mr. Mailloux, or any other member, has the opportunity to-night of presenting resolutions which may entirely revolutionize our course of procedure, and which may be adopted to-morrow. Rule No. 8 reads: "These rules may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendment shall have been given at a previous meeting." This meeting to-night is entirely separate from that of to-morrow. Any notice, therefore, given to-night could be acted upon to-morrow. The matter of elections is always a difficult one in a body like our own. Mr. Mailloux, who was one of our charter members, and who is familiar with our procedure from the first, may remember that at one time we had a method of electing by ballots distributed all over the country, a practice which is followed by societies similar to our own. At that time I had the misfortune to be acting as secretary, and it added very much to the burden of life to get those ballots out two or three weeks ahead and get them back three or four weeks behind, and having members object to my ticket, and others asking who got that ticket up. Now, to-night we come here, I think we may say without any caucusing. We do not come altogether unprepared; it would not be right to do so. We must cast a glance around the field of our membership and see those who are eligible by nearness to us to participate somewhat actively in our work. There are certain gentlemen we would be very glad indeed to have in the most prominent offices of the Institute if they could only be near us, and that is the feeling that they have. It was open to-night to any gentleman, when the nominating committee's report was presented to name any candidate he chose, and had that candidate been the choice of the meeting he would have been elected. And I think by our course of proceeding to-night we get as near to the real wish of the Institute as we could in any other way. At the same time Mr. Mailloux's remarks have weight and pertinence.

Capt. Michaelis withdrew his motion for a report from the council.

The President—There was another subject before our last meeting which was important, and that was the matter of junior membership, on which we arrived at no conclusion.

Mr. Phelps—I think that was what led to the action which Capt. Michaelis recalls. That subject was discussed at great length.

Capt. Michaelis—When a society is young, it requires very little constitution. Its affairs and its rules are simple and no conflicts can arise. But I was struck this evening by the very delicate duty that was imposed upon the president of appointing a nominating committee. That is a duty which I think he should not be compelled to perform at all. You can easily imagine cases where it would be exceedingly delicate and unpleasant. We might want a gentleman renominated to the position, and he

might be not unwilling to accept the office, and the whole Institute might wish the re-election. I think the selection of a nominating committee should not be in the hands of the president at all. They should represent the Institute at large. Now, some provision ought to be made in regard to that. Think how dangerous a power lies in so small a number of members as are usually present. We have three or four hundred members I believe. Very few members might be present at a meeting and somebody might present amendments to the constitution changing the entire policy and course of the society, and the other members would have no recourse whatsoever. There was no objection to that formerly, but as we grow we find that our constitution does require enlargement, amendment and possibly, in certain respects, restriction. I think it is really a very important matter. While the Institute is young and is in a measure local, I think the officers ought to be taken from the men who will work for it no matter what their age or previous condition of servitude may be. I do not think that that holds good as our institution becomes nationalized. That has been the course that has been followed by all the other large and kindred societies. In their infancy they were local. As we become nationalized we could well afford to return to the letter ballot and give each member of the society an opportunity of expressing his wish with regard to its policy and its officers. I hardly think that time has yet come, but I have no doubt it will in the near future. Something ought to be done to relieve the president of this delicate and possibly very disagreeable duty of nominating a committee who are to report, possibly, on his own successors or himself, or his friends. I do not think any harm has been done. I think the committee has reported an excellent ticket. I do not think the nominating committee ought to be officers of the Institute.

Mr. Phelps—I think, Sir, that neither the constitution nor the rules deal in any way with the question of how nominations are to be made, so that the remedy for this state of things would be very simple. It would be merely that at any time before an election a nominating committee should be elected. But after all a nominating committee is not an authoritative body at all. As the president has very clearly pointed out, the election is in the hands of the gentlemen who vote. Anyone may make any nomination that pleases him.

Mr. C. A. Terry—I think the difficulty we all labor under is this, that the nominating committee having brought in a list of nominations under the present custom of the society no one feels at liberty without treading on some one's toes very severely, to speak of any other person. The point on which there could arise any difference of opinion at any time, is apparently the matter of the presidency. If we could nominate a president by first having a general nomination on the part of the members by ballot, letting the few leading names which are brought in as the result of that ballot be understood to be the candidates, as they doubtless would, that would relieve us and would relieve the nominating board of all question and all disagreeable duties in that connection; and then the other officers I think would follow on without any question as regards the members of the Institute. But in the case of a nominating board there might be two in favor of one person and one opposed, or there might be three in favor of three different individuals, and under the present custom they could bring in but one name, yet if three names could have been brought in it would leave the way open to a much pleasanter and easier, and probably a more satisfactory election. I think the easier and more feasible way for our Institute would be to have a general nomination for the office of president, and then select from the two who stood highest.

Mr. R. W. Pope—Could not these points be covered to a certain extent, especially the one brought up by Capt. Michaelis, by the nomination of a committee to-night, or the election of a committee to-night to serve the ensuing year? It is not provided for in the constitution. There is no nominating committee provided for. But if this meeting to-night should select a nominating committee of three or five or any other number, and independent of the council, that committee would be in force and ready to act previous to the next election, and relieve the president from the delicacy of appointing a committee where he might perhaps be himself a candidate for the office.

The President—It seems to me gentlemen, that out of the various suggestions that we have received some better line of policy might be selected or devised. At the same time I would like to point out that under the old method which prevailed, the council was practically a self-electing and self-continuing body. By selecting a ballot to be sent out in advance to the members it partly chose its own successors. Now, to-night, the election is open to all. Under the old method it was not open to all. It was only open to such as the council chose to select for the ticket.

Capt. Michaelis—I think I will renew the motion I made last year. It is a delicate matter and I think we ought to hasten slowly and not prepare something that we may be sorry for, if we pass it now. I move you now that this subject of amendments to the constitution be again referred to the council, and that they be instructed to make a report at some special meeting to be called by the president next fall or winter.

Capt. Michaelis' motion was seconded and carried.

Mr. Higgins—I should like to ask if it would not be possible to conduct an election somewhat in this wise: To have the ballots sent in by mail from all members, and at a certain time before each meeting to have the ballot box closed as it were, and all the ballots counted, and of the two members receiving the highest number of votes, and in the case of managers, etc., the officers receiving the highest number be elected at the regular annual meeting by those present. That would leave the choice divided between the whole Institute and those present, leaving the responsibility mainly, of course, with those present, but at the same time leaving the general choice open to the whole Institute.

The President—Gentlemen, there is no motion now before us. I think there is no objection to the fullest and freest discussion of this question. One of these days it is going to be very vital to the prosperity of the Institute. At the present time I think we have a common feeling with regard to the question, but it is well to look ahead and avoid all possible opportunities of dissension. For that reason I do not feel like checking the discussion, although we have no formal motion. On the other hand, should there be no desire to continue it, a motion to adjourn is in order.

A member suggested, as a method of making nominations, that a circular be sent to each member containing a set of questions, such as, "name your choice for president, vice-president," etc., with blanks for the answers after it; those questions and answers to be assorted by the secretary, and the number of votes to each person for each office tabulated; then, say the three highest of each office to be put in nomination.

Mr. G. B. Prescott, Jr.—I think a society in this stage is very much in the condition of a school-boy who is continually outgrowing his clothes. His parents, of course, do not want to renew his clothing any oftener than they can help, for usually it is an expensive operation. While there is no doubt that this society is growing, and has already changed its clothes in the shape of rules or regulations once or twice, I think that these rules as they are at present are quite sufficient to last another year, and during that time we may progress so far that we may have to change again anyway, and as we can get along with our clothes as they are, I think we had better let the school-boy stay as he is.

Mr. R. W. Pope—This question of amending the constitution has always been up at about every meeting of every society that I was ever connected with, and I agree with the last gentleman who spoke as to the impossibility of making rules that will suit for all time. The most important matter that comes before us now is in regard to elections, and if we can provide for the nominations satisfactorily I do not see any objection to the rules as they stand, although they are crude in many respects. One of the defects we encounter in the mailed ballot is that the local members are not only fully conversant with the names and claims of the candidates and with their activity in the interests of the Institute, while those members who are at distant points would find it very difficult to acquire such knowledge, and must also be less familiar with the workings of the machinery on the spot. I believe that if we can provide an unbiased nominating committee who shall hold office from year to year, that is, as I suggested before, if we appoint one to-night from the body of this meeting who are not officers or members of the council, who shall hold office until next year, it would meet one of the objections that have been brought up as to the delicacy of the task of the nominating committee appointed by the president. This is a regular annual meeting, and it is very proper that it should be done at this time. The committee will have no active work to do, and they can begin say three months before the next annual meeting and canvass and be prepared to present a good ticket.

Mr. Vansize—The only objection I see to the proposed plan of Mr. Pope is that it would cut off the members who might become connected with the society during the ensuing year from the participation in the nomination of officers. It seems to me that the solution of the difficulty could be had in this way—that at the next annual meeting we take an informal ballot, and of those individuals receiving, say the three highest numbers of ballots, we take the first two and select from them a president, or, say, the first three, and in that way we might proceed with nominations for the other officers. In that way I think that the difficulties which beset the president and the nominating committee could be obviated, as well as the objections to the ballot by mail. It would be very desirable if the matter could be discussed in the technical journals which circulate throughout our membership, and it might be well to put this matter in the form of a resolution which could be referred to the council as tending to influence their action under the resolution proposed by Capt. Michaelis. For instance, we might make a resolution requesting the council to consider the feasibility of the plan which I have tried to outline.

Mr. Phelps—Since we are falling into a discussion without a motion, which, however, may be very useful, I would like to say a word or two more. Our rules simply provide, I believe, that the election shall be by ballot; that is as far as the rules or the constitution take cognizance of the procedure of elections. Now, why need we have a nominating committee at all? Why may we not simply come here on the night of election with an open field for any member to make any nomination whatsoever? There will naturally be—there always has been, and I suppose always

will be—in such societies more or less preparation in the way of members getting together and discussing the election of this, that, or the other person. Now, there is an absolutely free chance for all to make any individual effort, or any combined effort, to nominate any one whomsoever. Our rules as they stand offer no difficulty to the utmost freedom of action in that regard, and I think if to-night we had no nominating committee whatsoever that we should have elected a satisfactory board which I think now we have done, and very likely it would be much the same board. It does not seem to me that we need any particular action in respect to our rules on this subject. If we elect a nominating committee it would perhaps have even a more formal effect and be more of a deterrent of other nominations than the more informal method of appointing a nominating committee at the meeting simply for the purpose of having a ticket presented. It often happens in other bodies that tickets grow up spontaneously. Sometimes there will be two tickets hardly distinguishable from each other, one nomination or two being different from the nominations on the other ticket. But in the absence of any machinery for nominations, I think they would be brought before us by spontaneous combinations of the members.

Mr. Mailloux—I cordially approve of what Mr. Phelps has said, and while I feel that the nominating committee as such has no *raison d' etre,* and that it is an unpleasant complication of machinery, that it is not necessary for any material change in the constitution to be introduced that we may find the remedy. I think, however, that Mr. Phelps will find that he is really corroborating what Mr. Vansize said before him, and I would say that if Mr. Vansize will put his proposal in the form of a motion I shall be glad to second it, because it seems to me that he has presented to us what appears to be the most agreeable and adequate solution of any that have been suggested this evening.

Mr. Phelps—If you will pardon me, one word more. I agree exactly with Mr. Mailloux's desire, but the rules take no cognizance whatever of methods of nomination. It would have been perfectly open to us to-night, when the order of elections came—it would have been perfectly competent—for any gentleman to move an informal ballot—that may be done next year—any time—and to move as many informal ballots as may be desired to get at this very point. It does not require any action to accomplish that.

Capt. Michaelis—It appears to me that this discussion is very germane to the resolution that we have just passed. I think, however, that while it is very pleasant to exchange our views and get at the gist of these things, I would recommend that these gentlemen who have made, some of them, very happy suggestions, follow the resolutions and submit them to the council, who have now full power to act in the matter. In regard to the plan that has been last proposed I want to say one word. We have a national characteristic, and it holds good in politics of the state and in politics of societies. There should be no taxation without representation. Now, that is the American principle, and it will be carried out everywhere. You cannot restrict it. I am here as a granger member of the Institute. The granger members are in the vast majority, and they have a great interest in the Institute. And while they do not as yet care to vote, I fully recognize the difficulties that the president has suggested from past experience, and I believe that the time has not yet come when we should again revert to the letter ballot which, after all, is the only fair mode of election. But I think that time has not yet come. But what you want is to get at the views of this great majority of our members—of our grangers. The only way that remains is this nominating committee. I think that this nominating committee ought to be elected so long in advance that they can by their own effort find out what the sentiment of the great mass of the membership is in regard to its head, and I think a nominating committee at present can arrive better at the views of the members than a spontaneous expression of opinion at an annual meeting attended by a limited number. I think the council in its wisdom should formulate some way of electing or appointing a nominating committee that should represent the different sections of the country, say a committee of five, and that they should take the trouble to find out the views of members. Let their report be considered the regular ticket. That ticket would come before the Institute with the endorsement of regularity and as reflecting the views of the members, and of course the chances are that it would be elected. It usually is.

Dr. O. A. Moses—Mr. President, it is a well accepted maxim in the management of large political bodies that the preparation of business, the suggestion of it, should be confided to a few, the adopting of it to many, and the execution to a few. Now, in a society of this kind, which numbers among its members many extramural ones, it seems to me that the views of those who are beyond us should be heard, particularly in these days of rapid transmission of thought. It would seem to me, though I beg to state that my view is after all the digest of the many views I have heard expressed, that as good a method as any to pursue would be for the nominating committee, of a few, to be appointed, whose duties should be to a certain extent to carry out the traditions and policies of those who are for the time being in power. Every society has, or should have a policy. That policy should be a definite one, calculated for the general advancement of the interests represented by the members of the society, and no one is supposed to better understand those interests than the head of the society at the time. He is going out of office, and he can in a certain way delegate his powers to a larger number than himself who will consider his views, and those, perhaps, of the council as expressing the best policy of the society. I say that as a reason for the appointment of a nominating committee. That nominating committee should consider names well selected. While they are deliberating upon them, which might be during the course of one or two hours at the meeting held for that purpose, those who feel that they have friends who should be represented in the councils of the society should be at liberty to put in what is called an opposition ticket, the object being not to oppose, but to give an opportunity for those who think there are others well adapted to be represented in the councils of the society an opportunity to be there as representatives. Now, that is not all. The time for the selection should not be immediate, because those who are present represent as a rule a small number, a small fraction of the society. A certain time should be allowed to elapse, say thirty days, before a final vote is taken upon those nominations. There are two tickets, then, always in the field, one the regular nomination and the other a ticket of opposition, by courtesy, perhaps, but still another ticket in the field. It is very true that the regular ticket will generally be elected, but at the same time it gives members an opportunity, in case there is a good reason, for the representation of certain persons on the board. Then there is the great advantage that there are two tickets in the field.

Mr. R. W. Pope—I might say in connection with the remarks of the gentleman who has just spoken, that it has been the purpose of the council to make the Institute of the same value to members outside of New York as to those who are in this vicinity, and that is the policy we propose to carry out. How shall the outside members be enabled to participate in the election with the same degree of satisfaction as those who are able to attend the meeting? I presume that much can be learned from the proceedings of other societies in this respect, but I am not able to say just how. In regard to the method proposed by Mr. Vansize, I have known of a similar plan being adopted in other societies and it has worked very satisfactorily.

The President—Just casting a glance casually over the council as it will be constituted during the coming year, I find that, beside the secretary and treasurer, the country members will have a majority in the board, and it should be so. Our constituency is far larger outside of New York than it is within, and I may say that we have almost as large a constituency in the four quarters of the globe as we have within our own city. This organization is not only national but international.

Gentlemen, we have before us a very interesting programme for to morrow. I trust the attendance will be large, and I hope the discussions will be entered upon with zest, and will be valuable and instructive. I trust that every opportunity will be met on the part of members to be in attendance, and I take the pleasure of extending on behalf of the council an invitation to all such gentlemen as may not be members, who are interested in our work, to be present, and we shall be very glad to have members bring their friends so that they may see our work and judge of its extent and value.

The auditing committee has presented its report, which says:

"Your auditing committee has examined the accounts of the treasurer and secretary, as submitted to them to-day, and find them correct."

It is signed George A. Hamilton, F. W. Jones

The meeting then adjourned.

GENERAL MEETING—WEDNESDAY, MAY 16.

The meeting was called to order at 10.30 A.M. by Mr. T. C. Martin, vice-president. Mr. Edward Weston, the president elect, was unable to be present at the opening of the session, being kept at home by illness.

The Chairman—As you are aware, gentlemen, Mr. Edward Weston was elected president of the Institute last night. I have been informed that he is not at all well, and that it is possible that his illness, while it may not wholly prevent his attendance, may delay his arrival here this morning. I think it would be well, however, if we were to proceed immediately with our programme, and I will therefore present, as first upon the programme, the paper by Mr. P. B. Delany on the "Protection of the Human Body from Dangerous Currents;" and as I have promised Mr. Delany to read the paper for him, I will ask Professor Anthony if he will preside while I do so. (For Mr. Delany's paper see p. 244.)

DISCUSSION.

Mr. G. M. Phelps, Jr.—I suppose it will be somewhat difficult to bring the merit of the proposed protection to the test of trial by linemen, or by other persons. Probably there will be few investigators enthusiastic enough in determining the possibilities of

this protection to submit their persons to a test. But unless electricians share the sensibilities of the Anti-Vivisection Society, a great deal might be learned as to the efficacy of the means of protection suggested by Mr. Delany by judicious experiments upon animals. I suppose there will be an opportunity to get an abundant supply of dogs of various sorts the latter part of the summer. I make the suggestion as pointing out a method of testing the efficacy of this means of protection. I am quite serious about it. I can see no reason why very satisfactory tests might not be applied to various animals, and some of the physiological questions implied in Mr. Delany's paper be determined to a great extent.

Specimens of the protectors were handed around the room for the inspection of members.

Mr. R. W. Pope—Mr. President, one of the difficulties encountered in the practical application of a safeguard, according to my investigations, has been the difficulty in enforcing its use amongst the very men whom it is intended to protect. I have heard it stated that miners were averse to carrying safety lamps, and we all know that there are insulated pliers now on the market, and that india-rubber gloves when perfect serve as a protection; yet men go out on their daily duties without taking even these precautions, and consequently we need something more than the invention of a device that will perform its duty in order to save lives. If men are so careless and regardless of dangers as to go out on their duties without preparing against them, I do not see how we can do anything to wholly prevent accidents.

Mr. J. Wetzler—In looking at the question from another point of view, it strikes me that the question which is involved in the fatality of an electric shock depends as much on the electric work done upon the body as upon the potential. Let us take, for instance, the case of a man struck by lightning. We frequently hear of men having been struck and surviving. Here, without question, the potential must be at least many hundred thousand volts. Yet, on the other hand, we see a man touching a wire of 1,500 or 2,000 volts and being killed. In one case we have an enormous potential, but an exceedingly small current; in the other case a small potential, comparatively, but a large current; yet in the latter case the electric work far exceeds that of the lightning stroke, and the man's death ensues. Therefore I should say that the question involves the electric work done upon the human body as well as the potential; and if by means of such an apparatus the work done in the human body can be decreased, I think it would have in that sense some value; that is, if you could shunt a large part of current a man's life might be saved.

Doctor Vander Weyde—We have lately seen in the electrical journals assertions about the voltage that people could stand without injury. It has been stated that a thousand volts could with perfect impunity be taken. But those writers forget that there are two elements to be considered—the potential and the quantity as stated by Mr. Wetzler. When we have a great potential, as in a friction electrical machine, we may have, as Professor Mayer in Hoboken lately showed, many thousand volts potential but no quantity. It will jump easily a distance, but the quantity transmitted is very small, so that it is harmless. But when we take the other extreme, larger quantity or a great number of amperes, it is different. We find that in the thermo-electric pile there is not electromotive force sufficient to penetrate the skin. There is not enough electromotive force even to pass through the liquids of the body. In the galvanic battery we have electromotive force if we use a sufficient number of elements, and we have quantity if our cells are large enough. There we may have a shock, and a battery of that kind, as large as Sir Humphrey Davy used of some four thousand elements may be fatal to an experimenter. It is the relation between the two. There must be a sufficient number of volts and a sufficient number of amperes, both, in order to destroy life. That is the case of lightning. Usually lightning is fatal, because there is sufficient quantity, and at the same time there is electromotive force, as we see by the enormous length of a stroke of lightning. So it is with dynamos; when the electromotive force is combined with sufficient quantity then it becomes dangerous; but I want to impress upon all that electromotive force alone, without quantity, is harmless, and so the heavy currents alone are harmless. It is the combination of the two in which lies the danger.

Professor Elihu Thomson—I quite agree with Dr. Vander Weyde in the opinion that it is not a question of volts or current alone which determines the fatality of a shock. It is quite possible, no doubt, to take a charge from the human body equal to many thousands of volts. One may mount an insulating stool and be charged to a potential of ten or fifteen inches of striking distance and have it discharged from him without the slightest inconvenience—with no more of inconvenience than would result from the discharge through his body of a very small Leyden jar. I have had that experience, and I can testify, that even though such a discharge as that goes directly across the body of a person it has no harmful effects other than a very slight shock, causing a twitching of the arm. In all cases of dangerous shock it seems to me we must have a resistance so low as to permit the volts to send a current of a certain volume through the system. If that current is not attained, it is doubtful whether harmful results will follow. If that current is attained, the harmful results may follow. If we could imagine a man constituted so as to have not more than an ohm resistance, he might, it is conceivable, be killed by a very small voltage, between any two portions of his body, between which are situated vital nerves, nerves whose action is required to keep up the functions of the respiratory organs or the heart. The human subject undoubtedly differs very greatly in resistance at different times, and a fatal shock may be obtained in one case at one time which would not be obtained by the same subject at another time with equal volts, much depending on the moisture of the skin, and probably the amount of salty matter in the blood. The layer of fat which exists underneath the skin acts as a sort of insulator. All these things will have an influence. We have reason to believe, moreover that susceptibility varies very greatly in different persons. I quite agree, also, with Mr. Phelps in the necessity of some really scientific investigations tending to clear up this question. Those investigations, I think, could be carried on with the lower animals, and very valuable data arrived at, as to the passage of the current in certain directions through the body; for example, whether the current in its passing includes, say, the pneumo-gastric nerve, which, if it does not act is sure death every time. The heart must beat in order that life be sustained, and death will occur from heart failure if the heart is not kept beating. If the respiratory organs fail in like manner—if, in other words, the nerves controlling the respiratory functions have their vitality exhausted, that will also be a cause of death. The whole organism depends, I think, upon the nervous system and it is also a possibility that such a thing as nervous polarization may occur. The molecules constituting the nerve fibres may become set or polarized, so that the brain's excitation cannot reverse them or cannot bring them back to a normal condition. That idea has been put forward as a suggestion in regard to recovering—whether it would be likely that a discharge passed in an opposite direction would, as it were, depolarize the nerves and assist recovery, followed by artificial respiration and other means at command. It has been stated, I think, by D'Arsonval that in his opinion the alternating current is not so apt to produce fatal results as the direct current, and particularly direct currents in the nature of sudden discharges or shocks similar to lightning discharges; a large volume of current sent through in intermittent impulses or sent through in one impulse of considerable power. He, I believe, holds to the opinion that in cases of injury by alternating currents resuscitation may be effected, in many cases, by artificial respiration. If this is the true state of the case, it would seem that polarization had something to do with it—polarization of the nerve structure which is prevented by the fact that the alternating currents are continually reversed. The fact also is certainly true that cases of very severe injury are known, where men have been subjected to a very high potential current and all the evidences of the passage of a heavy current through their bodies have been found, and the men have not suffered any great inconvenience other than burning of the hands, so that it would seem as though a critical condition in some cases existed which was not present in others. Whether the person himself has any extra power of resistance or whether his nervous system is so toned up as to be capable of recovering after he has been partially injured, is a question which would naturally arise in connection with this case. I cannot agree that it is a question of one volt more or less whether a man is killed or not, I think the time element is probably the most important of all. There are cases in which men have been struck by lightning, and as you all know have recovered. Discharges of potential of millions of volts have passed through their bodies and they have recovered, and in such cases the discharge was undoubtedly a sudden one, and the current passing must have been very considerable. I cannot regard a lightning flash as an example of a small current. The heating effects which are present in such cases are sufficient to show that the current may rise to very many hundreds of amperes. For example, if a lightning flash will deflagrate a small iron wire in a very small fraction of a second, it means that current, not volts, has done the work, and not only that, but a very large current. It may have existed for but a short time, but it certainly did exist, and the very suddenness of the action is in favor of very high current flowing. We have numerous instances of telegraph and telephone wires melted and other small wires melted by the electric discharge from the clouds, and when we consider the conditions we must see that the current is large. We have only to look at a lightning discharge to see that it may appear to us as thick, sometimes, as a telegraph pole. That, if it means anything, means a body of vapor highly heated, of some considerable area. But lightning discharges, according to my observation, are not always single and alone. They are sometimes repeated half a dozen times down the same path, and it is not to be wondered at that a man receiving, say, a discharge of half a dozen flashes down the same path in rapid succession might be killed, whereas a man receiving one flash, might escape. I have noted that fact by simply keeping my head going during a thunder storm and keeping my eyes fixed in one direction, so as to catch the flashes, and they arrange themselves in parallel lines, oftentimes. I have counted as many as six in that way, very quickly following each other.

Dr. Vander Weyde—I had an opportunity some twenty years ago of making experiments upon the conditions of different persons in regard to heavy shocks, when I was professor in the Cooper Institute. We had a Rhumkorff coil which made sparks at twelve inches. I attempted to increase the length of sparks by some improvements, by taking away all possible edges on the binding posts, and I increased the spark to 16 inches. In making those experiments I was a few times actually knocked down—not exactly knocked down—but I had to *sit down*; I could not help myself. I spoke of it to Dr. Jerome Kidder, well known as a maker of electric apparatus for medical purposes. He said the idea that such a Rhumkorff coil as that was exceedingly dangerous was an exaggeration, and he was willing to take the strongest shock I could give. I said to him, "If you want to take the risk, I am ready, but bring witnesses." He came with witnesses, and one of them was a reporter of the New York *Tribune*. I gave Mr. Kidder small shocks at first, gradually making them larger and larger and he stood it perfectly well and it did not knock him down. He had great power of resistance. The next day an article was published in the *Tribune*—it was a sensational article—headed, "An Error in Science Exploded," and there it was said that all the talk that electricity could kill was nonsense; that the strongest machine which ever had been made was now at the Cooper Institute; that it was the strongest was proved by the fact that it had cost not less than $400 (laughter), and that Mr. Kidder, the well-known electrician, had stood all the shocks from it, and it gave a great many details which are very amusing to a man posted in electrical science.

Dr. Moses—The proposed experiments on animals would be very interesting, but it would be very difficult to make the conditions sufficient to satisfy all the requirements that are necessary for accurate experimentation. If you consider that the resistance of a man's body may vary under certain circumstances from ten or fifteen thousand ohms down to four or five ohms, it is necessary that the experiment should be conducted in some uniform way. The skin is an excellent insulator, the blood an excellent conductor, the perspiration an excellent conductor. The varying pressure that we apply in coming in contact with a conductor is a cause of immense variation in the amount of current that passes through us. The skin varies in thickness, so that it is necessary in making experiments to take one constant place and one constant thickness. It will be a very difficult thing to try the experiment, but still it would lead to good results.

Mr. Martin here resumed the chair.

Mr. Francis B. Crocker read a paper on "The Possibilities and Limitations of Chemical Generators of Electricity." (See p. 248.)

Mr. Crocker continued as follows:—In regard to primary batteries I do not wish to be regarded as entirely skeptical. As I have said, the possibilities are almost infinite, but there are certain facts which cannot be overcome, which might as well be looked at straight in the face in the beginning rather than after a company is formed to exploit a primary battery and the failure occurs. There are certain legitimate applications of primary batteries even in their present state of imperfection. For example, a primary battery, Leclanché cell, is very satisfactory for ringing electric bells—we do not need a dynamo for that purpose—and for telephone work, and even for small power uses, although I have not yet seen the battery which will practically generate electricity for a reasonable price. As a luxury we can have a battery, or for some very special work like a dentist's or a physician's work, where a horse-power hour may be worth $1,000. There, one could afford to use the silver-chloride battery and throw away the silver.

DISCUSSION.

Dr. Moses—We are very much indebted to Mr. Crocker for the able paper, and we cannot too highly value the time, the energy and self-abnegation devoted to preparing such a paper. There are some questions he will permit me to ask him that will lead to others, and in that way to a useful debate. I notice that in this table D you have used chlorine, bromine and iodine for the three elements that you combine. Why did you select those whose atomic ratios are perhaps less accurately determined, and which are not absolutely considered as elemental in their character? Why did you not, perhaps, take a combination of oxygen or even carbon for that purpose?

Mr. Crocker—In the first place, as I have said, oxygen, pure and simple, cannot be combined directly with zinc. You cannot have free oxygen. It will not dissolve in the solution—to a certain extent it will, and it would be possible to use it, but only in a very delicate way. Whereas, bromine, chlorine and iodine will actually be dissolved in the solution and be used in an elementary state. So far as the elementary character of bromine, chlorine and iodine is concerned I have never heard it assailed before. If you mean that all so-called elements are not elements, and that hydrogen is really the only element, why, then, of course, they go with the others, but so far as I have ever heard they stand on the same basis as carbon, oxygen and so on; and, furthermore, they constitute a series of chemical elements; they are related to each other, and in that way they are successive elements, so to speak. The results obtained are more clear and more instructive when a series of elements is used in that way than when you pick out elements at random. The real depolarizers are those elements, chlorine, for instance, and bromine and iodine. Now, chromic acid itself is not a depolarizer; it is merely the oxygen it contains. In that case you use oxygen, but you do not use it pure and simple; it is a combination with chromic oxide, and therefore the oxygen is complicated.

Dr. Moses—Would you also tell us why you prefer not to determine accurately the amount of water that you used for solution? Do you not find, since water is essential, that its chemical equivalent and its relations to the substances in solution should be just as accurately determined, though we are inclined to consider a solution is not a chemical combination? Still, for these purposes these elements go through combinations through the solution. Therefore, why is it not essential to determine about the water?

Mr. Crocker—The water is merely a medium for the action to take place in; that is really the chemical fact. Of course I could put in the tables in the case of the weights, about how much water an ordinary solution would require, but that really would be mere guess work. The best you could do would be to find when you obtain the maximum results, and that would be a very difficult question; but I find that it makes very little difference in electromotive force whether a strong or a weak solution is used. It makes *some* difference. The stronger the solution the less the electromotive force. The variation may amount to, say, between $\frac{5}{100}$ and $\frac{1}{10}$ of a volt; with the concentrated solution the electromotive force would be that much lower than in a very weak solution. That is because there is so much tendency for the metal to go in solution. The solution is already satisfied; whereas if the solution is weak it has an affinity for the metal. That is the way I explain the fact.

Dr. Vander Weyde—I cannot refrain from paying a compliment to Mr. Crocker (applause) for his very useful labor. It was just the thing that was needed. I wish to make one remark about the function of water in the battery. I would like to hear Mr. Crocker's opinion about a widely adopted theory that the water is the main agent in batteries, that it is the decomposition of the water which does the work, that the oxygen of the water combines with the zinc or other metal that is oxydized, and that hydrogen is developed, and a layer is formed which is the cause of polarization, and in order to get rid of that hydrogen the depolarizers are applied. I would like to hear Mr. Crocker's opinion about that theory.

Mr. Crocker—As regards the function of the water in the battery, it may be called a metaphysical point. (Laughter.) The water may act and give up its oxygen. The hydrogen may give up oxygen on one side and turn around and get some more on the other side. So far as I can see it is water all the time. It is not changed, it acts as a transmitter; that is all it does. It acts as a vehicle. But after the action is over there is just as much water there as there was before, unless it has evaporated; and, in fact, some chemical actions involved in batteries produce water, and in that case there would be more water at the end of the action than there was at the beginning. Then the action would take place exactly the same in the anhydrous state, whenever it is possible to get that state. For example, with a fused salt the action is exactly the same. The zinc would combine with chlorine in fused chloride of zinc, as I have myself proved by experiment, and give substantially the same electromotive force as it does in the presence of water. Water is merely a means of getting a liquid which it is necessary to have as an electrolyte. Electrolytes must be liquids. Now, you can obtain those liquids by fusing your solid electrolyte or by dissolving it. Therefore, I always look upon the water as a medium in which the action takes place.

Dr. Vander Weyde—But the question naturally follows that if the zinc is oxydized by the oxygen, what becomes of the hydrogen at the point of contact with the oxygen? Then there is more than a mere vehicle. We see that the hydrogen is developed at the platinum or silver plate.

Professor E. L. Nichols—I would like to supplement Mr. Crocker's statements by an observation in reference to the behavior of iron, and I presume what is true of iron will be true of other metals which form two salts. If you take iron and platinum in a solution which will produce a ferric salt and let the cell stand so that the iron becomes surrounded with a film of its own salt, then the ferric action will gradually cease and ferrous action will take place. After the cell has stood some time, the electromotive force will rise about one fifth, and you can instantly restore it to the condition it had at first. If you take a porous cell and separate your iron and platinum, put the oxydized solution in connection with platinum, and then around the iron something which will produce the ferrous salt, you will find that that battery has about one-fifth more electromotive force than in the case of the ferric. It seems as though a more successful battery ought to be made with iron producing the ferrous salts. You gain almost enough to make up the difference between iron and zinc; but the behavior of iron is very unsatisfactory, and the reasons for it are not always very clear. It seems as though oftentimes it is due to the formation of oxydizing films which run the resistance of the cells up to an enormous amount. I have known the resistance of bichromate cells to run up to several hundred ohms in the course of an hour or so by the formation,

apparently, of an insoluble film of some form of iron which was almost a non-conductor. Perhaps iron, if worked out patiently, might give us a very cheap metal for a battery and reduce the cost of galvanic electricity very considerably.

Mr. C. O. Mailloux—I would like to ask, in view of the discrepancy observed between the calculated and determined electromotive force, what standard Mr. Crocker used, what value he assigned to it, and upon what authority, so that we may know what kind of a volt he used.

Mr. Crocker—I used constant Daniell cells, but independent ones set up separately, and with chemically pure sulphate of zinc and sulphate of copper, solutions half saturated. Then I further checked the results by two electromotive forces which I happened to know and had previously determined very many times, and those are the bromide combinations of zinc and iodide. That in itself is an excellent standard cell—free bromine and zinc. It gives an electromotive force of 1.79 volts. That is the result, I suppose, of a thousand experiments. Therefore in going through my experiments when I came to the combination zinc-bromide and found that it gave an electromotive force of 1.79 volts, I felt perfectly at home, because I had been there so often before; it corroborated my standard. Then the combination of zinc and chlorine, 2.11 volts was also very frequently determined, and of the Upward battery which came out about a year and a-half ago in England, the published electromotive force was 2.11 volts. So there were several corroborative facts. So far as my experience goes, a standard Daniell cell does not vary very much in electromotive force.

Professor Thomson—I would like to say just one word on this subject. It has probably been a common experience of those having Daniell cells in operation to notice, if the solution is not kept up to a high degree of strength, that oftentimes the upper part of the copper will be eaten out, and the electrolytic deposit of the copper made in the lower part of the cell where the solution is strong; or, in other words, there is an indication of a difference in the volts which carries on a sort of plating action on the copper plate itself. Whether this be due partly to the effect of the acid, or that the solution comes through from the porous cup and floats on top causing a difference in the electrolytic condition of the fluids alone, setting up current, I do not know. But it recalls to my mind an observation several years ago on the effect of simple heating of the solution. Putting at the lower part of the test tube a little spiral of copper wire and carrying out a connection by an insulated covering from that spiral, filling up the test tube partly with sulphate of copper solution; putting another little spiral near the top of the fluid and then heating we find a difference of voltage, and it amounts, I think, to something over one-twentieth of a volt, if I remember the results of the experiments correctly; showing also that a solution of the copper—if we short-circuit such a battery—will be expected to take place and a deposition of the copper in the cold liquid. In other words, the hot liquid is more of a solvent than the cold, although it is a sulphate of copper solution. Whether Mr. Crocker has taken into account the temperatures of the solutions in making these tests I do not know.

Mr. Crocker—I made the tests at the normal temperature. It did not vary five degrees from 68 F.

Professor Thomson—It is probably well understood nowadays that not all the elements are to be considered as real elements as we find them. I do not mean that they are decomposable into hydrogen, although I think that quite possible, and perhaps even to a far more primitive condition than hydrogen if we could use forces which we have not at hand—I mean the celestial forces. I mean that each particle of copper known to us is a combination of copper with copper; that the atoms really form a molecule which is a real compound. Two atoms or more atoms may be found united, but it will certainly take something to decompose those molecules even though they be combinations of the same atoms. I am struck with the results obtained with aluminum in the work of Mr. Crocker. We find actually that this metal so hard to get at is really capable of giving an electromotive force less than zinc; so that it would seem as though by the proper use of zinc in some way or other we might separate aluminum. In other words, its electromotive energy is very much less than zinc, and in some cases not very much different from iron. In the recently developed reduction of aluminum we find that carbon at high temperature reduces it with comparative facility, and it may be that after all, all we have to find is something which will fluidize or liquify the aluminum, and we would then find that even common materials like zinc or iron would separate these combinations.

Mr. Crocker—In regard to that aluminum question the same thing struck me that Professor Thomson points out. By my experiments aluminum is apparently less electro-positive than zinc. I do not think that is actually the fact. I think there is some loss which occurs—loss of electromotive force. In fact the calculated results are higher than those of zinc, and it might be that aluminum forms an insoluble compound on the plate.

Dr. Vander Weyde—It may be useful to state here that twenty years ago I attempted to substitute aluminum for platinum in the Grove battery. The result was negative. I scarcely got any current at all. It appeared that aluminum had not the power to decompose the nitric acid and produce the nitrous acid fumes customary when we use platinum in the Grove battery.

The Chairman—The next paper on our programme is that on "Compensated Resistance Standards," by Professor Nichols, of Cornell University.

It affords me the greatest pleasure to announce that our president, Mr. Edward Weston, who has been quite ill, has sufficiently recovered to be with us, and is now here, and that he will preside immediately after lunch.

Introducing his paper, Professor Nichols said: "I would like to state that the experiments I am about to describe had their origin simply in the desire to find something that could be used for a low resistance shunt or for a low resistance standard, and which would obviate the difficulty which every electrician meets with in electrical measurements on account of the influence of temperature upon conductivity. I suppose there is no correction which we are obliged to make which is so troublesome as this one of the temperature coefficient. If it were merely a question of change of the temperature of the laboratory, we could correct for that. We could determine our coefficient and make the proper correction; but whenever current flows it heats the wire to a temperature higher than that of the room, and in the case of heavy currents this difference of temperature will be a large one, and one which cannot by any ordinary means be accurately determined; and so there is always an element of uncertainty in the use of a coil through which a current flows, and this has proved so serious, as doubtless many of you know, as to lead to the discarding, for accurate work, of shunt methods of measuring heavy currents." (For Professor Nichols's paper see p. 246.)

DISCUSSION.

Mr. Wheeler—I would like to ask Professor Nichols if he has any explanation of the sudden drop at about 22 degrees centigrade. I would also like to say that Professor Thomson called my attention to the fact that he had made a bar by leaving the varnish complete all the way around, and then putting lampblack on, or graphite, and plating a complete copper tube upon it, and then connecting that at one end so that you could send the current through the length of the carbon.

Mr. Nichols—The only trouble is that the amount of copper required is so small that it is difficult to get a small enough amount. You must have 11 ohms of copper and that means a very small tube. The very slight change, in my opinion, is not due to incomplete compensation, but to accidental causes. It is very difficult to get rid entirely of thermo currents. It is perfectly thinkable that there might be some irregularity in the temperature coefficient which would make the compensation slightly incomplete. At intermediate temperatures I do not think it is noticeable.

At 1 o'clock P. M., a recess for lunch was taken.

AFTERNOON SESSION.

The Chairman—At the opening of our morning session I had to announce that through serious sickness our president, Mr. Edward Weston, who was unanimously electedl ast evening, was unable to be present. Mr. Weston has, however, made a great effort to be with us to-day and comes here from a sick bed. I think in securing the services of Mr. Weston in the presidency, the Institute has secured one whose international reputation will be of benefit to it through the coming year. The Institute, as you are well aware, is a society whose membership is not confined merely to New York, but extends throughout every state and territory of the United States, and includes to-day almost every civilized country. Mr. Weston's reputation as an electrical engineer is co-extensive with the membership of the Institute, and I am therefore very glad to salute him as my successor and now to present him to you.

Mr. Weston took the chair, and addressed the meeting as follows:

Members of the Institute and gentlemen: I am not quite so sick as our retiring president, Mr. Martin, would lead you to believe; but since yesterday I have made a few trips between the Equator and North Pole. I have been jumping from pretty wide extremes you see. To stop the too rapid motion I have taken considerable quinine, and it leaves me in a somewhat befogged condition of mind. I am, therefore, not feeling well enough to address the Institute in the way that I should do in accepting the presidency. I feel extremely honored by the kindness of your selection. I accept the office with grave doubts, because I question whether I can give so much time to it as our past worthy president has done, or can achieve in the same time so remarkable a growth for the Institute. I am informed that in the year of his presidency the membership of the Institute has about doubled—an indication of excellent work. The papers that I have read—and what I have seen of the proceedings—have been worthy of the society. The character of the papers shows a constant upward tendency. I hope it will continue so. We have nothing to be ashamed of in the past, and I hope we shall find nothing to be ashamed of in the future. I had intended to speak in full of the present state and future progress of electricity. I am unable to do that to-day. I really cannot undertake it. Therefore, I beg to

apologize for disappointing you. I am not in fit condition even to occupy the president's chair, and as Mr. Martin has suggested that he would rather withdraw to-day, I would like Mr. Upton, if he would kindly do so, to accept the position this afternoon. (Applause.)

Mr. F. R. Upton, vice-president, took the chair.

The Chairman—The first paper read was on "A New System of Alternate Current Motors and Transformers," by Mr. N. Tesla

Mr. Phelps—I would like about two minutes before the paper is read. I do not rise to propose a vote of thanks to our retiring president, because I think votes of thanks, like the resolutions in political conventions, "pointing with pride," etc., have become a custom more honored in the breach than in the observance. But I do feel that a word ought to be said—and I feel very confident that I express the general opinion—recognizing the zeal, the activity and the intelligence which has characterized the administration of the office of president during the past year. The growth in membership, the character of the work accomplished, and in general all the activities of the Institute during the past year, constitute a record to which I think we shall always look back with satisfaction and with reasonable and just pride. It has been a matter of astonishment to me to observe the amount of time and the intelligent effort which so busy a man as our ex-president has found it possible to give to the interests of this Institute. He has not spared himself in any particular; there is no work that he could do that has been left undone, and our condition at the present time is a sufficient evidence of the truth of what I say, and I have not the slightest doubt that all here present join me and feel that I make no more than a meagre statement of the facts. (Applause.)

The Chairman—Is any formal motion to be made and entered in the minutes?

Mr. Phelps—I think not, sir. As I expressly stated, I would prefer, as far as I am concerned, to avoid a formal motion. But the way in which my remarks were received sufficiently justified my belief that they expressed the general sentiment of the members present.

A Member—I would move that the remarks made by Mr. Phelps be heartily accepted, approved and endorsed by the society.

The motion was seconded by Mr. Wheeler.

Capt. Michaelis—I would merely like to add one word to the enconium pronounced by Mr. Phelps. I have been fortunate enough to be associated with our past president in the council during the past year, and I can heartily endorse everything Mr. Phelps has said. I would like, however, to call the attention of the Institute to one point in which they are indebted to our past president alone, and that is the valuable addition to our transactions in the shape of the bibliography that now appears with them regularly. That was Mr. Martin's idea, and it has been carried out by him. You all must know how much time such a thing has taken, and he has done that entirely of his own motion and for the good of the Institute. (Applause.)

The Chairman—I understand the motion to be that the remarks of Mr. Phelps be added in full in our minutes, and with the cordial approval of the members. All those approving will signify by rising.

The motion was unanimously carried.

Mr. Tesla, before reading his paper, said: I desire to express my thanks to Professor Anthony for the help he has given me in this matter. I would also like to express my thanks to Mr. Pope and Mr. Martin for their aid. The notice was rather short, and I have not been able to treat the subject so extensively as I could have desired, my health not being in the best condition at present. I ask your kind indulgence, and I shall be very much gratified if the little I have done meets your approval. (For Mr. Tesla's paper see p. 252.)

DISCUSSION.

Mr. Martin—Professor Anthony, I believe, is here, and as he has given this subject some attention, I think he might very properly supplement Mr. Tesla's paper by some remarks.

Mr. Tesla—I want to express once more my best thanks to Professor Anthony for aiding me in many respects, and I hope he will be able to explain many of the features in this system that I was unable to explain at present.

Professor Anthony—Mr. President and Gentlemen: I have been referred to as having had something to do with these forms of motors. I am very glad to be able to add my testimony to what Mr. Tesla has already given you in regard to their action, and I confess that on first seeing the motors the action seemed to me an exceedingly remarkable one. After my first visit to Mr. Tesla's works, some of the motors, I think these very two that you see here on the table, were brought to me to make some tests of their efficiency, and probably you will be more interested in those than in anything else that I might say. I am sorry I have not brought with me the exact figures that we obtained, but I can give you from memory something of the result. This little motor that you see here gave us about half a horse-power, and gave an efficiency of something above fifty per cent., which I considered a very fair efficiency for a motor of this size, as we cannot expect on such small motors to get as high efficiency as we can on larger ones. This, I believe, is the armature that Mr. Tesla calls the armature for high rotary effort. This little pulley, which is only about three inches in diameter, gave a pull of something like fifty pounds, as I remember it on turning on the current, so that you see the rotary effort is very considerable, and that is also shown in the quickness with which the armature will reverse its motion on reversing the relation of the two currents which pass through the two opposite coils. That could be done by shifting two of the wires, or simply shifting a reversing key in one of the circuits, and the armature would stop and reverse its motion so quickly that it was almost impossible to tell when the change took place. That shows also the very considerable rotary effort that the armature presents. This motor (referring to the second specimen) gave us, I think, about 1¼ h.p., and showed a somewhat higher efficiency than the other—a little over sixty per cent. This would run, with the armature as here constructed, almost at the speed of the generator even under a very heavy load. When the load was brought up to the maximum load, where the efficiency began to fall off somewhat, the speed of rotation was reduced. As I remember now, it was reduced to about twenty-eight hundred, and the speed, you see, kept up very nearly to that of the generator under heavy load.

I can add very little to what Mr. Tesla has already given you in regard to these motors. I have no question but that all of you would be as much interested as I was in seeing them work. That is really the best way in which to determine what the motors will do.

Mr. Tesla—Mr. President and Gentlemen: Professor Anthony just made the remark that the speed of this motor fell off when the load was increased. That was due to the fact that this armature was designed to secure a strong effort from the start. But if we make an armature which is only designed for synchronism, the speed will always be the same no matter what the load; only there is a disadvantage that at the start the rotary force is so small that it is apt not to start. It would generally start if put in a proper position, but if not put in a proper position it might not start. If we employ an armature consisting of a cut-away block of steel with a coil, it will maintain its speed at all loads. The importance of maintaining the intensity of the pole constant is that if this can be produced we can utilize, instead of the subdivided armature, an ordinary steel block with the same result. It is only desired to close the magnetic field. You can readily see, if the poles are fixed, that it is not necessary to subdivide the armature, if the intensity of the force is constantly maintained the same. But, if the intensity is not maintained the same, then it is necessary to subdivide, and generally in the results that I have obtained I have found that it is necessary to subdivide. I have also observed that in the tests of Professor Anthony the results obtained were superior. I attribute that to the fact that the dynamo has got a powerful field and a small armature and the field is very concentrated, and for that reason probably, the result is nearer a theoretical result.

Professor Thomson—I have been very much interested in the description given by Mr. Tesla of his new and admirable little motor. I have, as probably you may be aware, worked in somewhat similar directions, and towards the attainment of similar ends. The trials which I have made have been by the use of a single alternating current circuit—not a double alternating circuit—a single circuit supplying a motor constructed to utilize the alternation and produce rotation. I have carried on since the last annual meeting of the Institute the development and perfecting, as far as my time allowed, of a closed circuited armature—if we may so term it—related to the alternating field. That is, the plan which I used and which I brought to the notice of the Institute last year, was to make a laminated field and in that field to place an armature also laminated, winding upon the armature a coil which periodically is close circuited during the revolution by a suitable commutator or circuit-closing device. I have made several such motors on different designs and they uniformly start from a state of rest and develop power, and some of them show, at speeds close to the rate of alternations of the dynamo, a tendency to synchronize. Their rotary efforts in most cases is a little greater nearer that point than at other points. I hope sometime before a great while to bring most of these results before the notice of the Institute, and I would therefore prefer delaying further remarks on motors of this description. I certainly think there is a field for alternating motors, and there is undoubtedly an opportunity for obtaining motors which possess even some advantages over the continuous current motors.

Mr. Tesla—Gentlemen, I wish to say that the testimony of such a man as Professor Thomson, as being foremost in his profession, flatters me very much. I might say that I have worked in the same line with Professor Thomson at a period when the invention of Professor Thomson was not known to me. I had a motor identically the same as that of Professor Thomson but I was anticipated by him. I believe that although that peculiar form of motor represents the disadvantage that a pair of brushes must be employed to short circuit the armature coil, that such a form of motor may be made practicable for the simple reason that a motor represents a transformer, and such a transformer we well know we can bring to a very high efficiency. On the other

hand, the armature may be provided with conductors that are of comparatively low resistance, and it is a mere matter of making a perfect arrangement for short circuiting. You will see the advantage of this disposition of the closed circuit coil—that this action is always maintained at the maximum and it is indeed more perfect than if the polarities were shifted by means of a commutator.

The Chairman—Unless there are some other remarks on this subject we shall have to pass to the consideration of the next paper. I think thanks are due to Mr. Tesla for his paper. The next paper in order is "Underground Electrical Systems in Europe and America," by Professor G. W. Plympton, of the Brooklyn Subway Board.

Professor Plympton—Mr. President and Gentlemen of the Society: This is a place in which I should seek to stand for instruction rather than to impart any information. I have looked for a long time to gentlemen of this organization for information to guide me in the work I am doing. I shall be very brief with the so-called paper, and will give a little of what I have to communicate orally in the way of a description of some plates and a narrative of my journey.

After reading his paper (see p. 260), Professor Plympton said:

The impression that I had received from conversations with people who had seemed to know, was that a large part of the telephone service of Europe was buried in the streets. I was partly disabused of that idea by an engineer who had returned from Europe just as I was setting out. I went to London. I was furnished with letters to various engineers, by engineers and managers of telephone and telegraph companies and civil engineers. I first made the acquaintance of Mr. W. H. Preece in London, and learned from him that the postal telegraph wires were buried in the street, and that some telephone wires were buried with them—enough for the service of the post-office department. A telephone company enjoying franchises in London have run all of their wires overhead, as the manager informed me he could not put a wire underground without an act of Parliament. They bought their right of way over the house-tops. There are certainly wires enough in many places there. They do not compare in number and entanglement with ours in New York, simply because there is no such telephone service there as we are familiar with here, nor is there in any other place. I had submitted the question as to the material of the conduits. He said that after going through a good deal of experience they had adopted iron pipes for their conduits and drew their cables loosely through them. Wires were protected singly, and then two or three or ten or a dozen wires were twisted together and pulled through the iron pipe—generally a three-inch pipe, rarely larger than four inch. If it was necessary to make connection at some point not contemplated before the pipe was put down, they simply knocked a hole in the side of the pipe with a hammer and made the connection. When inquiry was made what they would do in case of so many subscribers along any line of telephone conduit, such as we have here in New York, they said that problem was not yet presented to them in London. I went on there to make another visit afterward. I simply examined the system in the streets. These pipes were buried about sixteen or eighteen inches, rarely as much as two feet, ending in little cast iron boxes about twenty inches by sixteen and perhaps a foot deep, fitted with an iron cover tightly cemented. They sent workmen out, and I was accompanied by Mr. Fleetwood to examine the boxes. They had difficulty in raising one or two. I asked why they were so tightly cemented. They said to keep water out. I asked if that was really the effect. They said they thought it was, but the first cover they took off showed me a box with about two inches of water in the bottom. In submitting the question of material of a conduit to Mr. Preece, he answered that iron was used because it would serve better to protect their wires from injury when the streets were dug up by workmen; pick-axes would knock everything else to pieces. He spoke well of our plan of creosoted timber, and took from a case in his office a piece of an old conduit put down in 1853. It had been in the ground thirty-one years. It came out perfectly sound. The cable had given out years ago. It is known that they began systems of telegraphy in Europe by burying all their wires. They tried to bury them along their lines of railway; afterwards dug them up, and now their wires across country are on poles. They are burying in some places in the cities.

Brussels I visited next, and there found a system of arc lighting. Wires were stretched along the street. None were buried. Telephone wires are over the housetops, the wire being in some cases a hard drawn copper wire, in others a silicon bronze. As the houses are high and the house attachments are high, these wires run pretty well up in the air, and as they are small they do not attract attention as they do here. That is the case generally throughout Europe. They use a small wire, and the housetop fixtures are so high that they are not apt to attract attention. A gentleman on the steamer gravely told me that he had been all over Europe and did not see any wires in the air at all; he knew they were all underground. As the chief manager of the telephone system was in Antwerp, I went on to Antwerp to get such information about such telephone service as was under his control. That was Mr. DeGroof. He very kindly offered his time to answer as many questions as I chose to ask. I thought of going on to Stockholm, for the reason that I understood the service was very good there, but I learned from Mr. DeGroof that everything was put up under his direction, and, with the exception of the framework on the housetops, everything in Stockholm was exactly duplicated in Antwerp. He thought that no telephone wires in Europe were underground except those that there were in the sewers in Paris. He proved to be not quite correct, though pretty nearly so. I asked about his housetop connections. He said all through the Belgian and Scandinavian cities they were on housetop fixtures. In Italy they were on brackets under the eaves, for the reason that the tiling of the roof does not support very kindly these immense wooden structures. To preserve some degree of coolness in their roofs they put on a triple tiling with little air spaces between the tiles, and it almost destroys the whole roof to put up a wooden structure. Hence they attach it by brackets under the eaves. The style of these you will have an opportunity to see, as I have had these systems extensively photographed in many places in Europe. Mr. DeGroof added that one company had come there with an electric lighting system—he told me the name—and had buried a cable for a short distance, with the intention of lighting the street. It was all buried and they were nearly ready to start, when the gas companies came forward and proved that they alone had the right to dig up the street—the right of canalization of the streets, as he expressed it. The whole plant was lost and lies buried in the street. He mentioned as an interesting fact that he tried a new plan along the shore of the Scheldt. He had just put up a mile of poles to support his wire. That was a pole line in Europe that they felt rather proud of. I had it photographed and received the photograph since. In Berlin the circumstances are not widely different. There is a series of lines under the municipal direction and some under the direction of the government. There has been a little friction between the two. The first official that I consulted assured me that all telephone wires were on the housetops; nearly all telegraph wires were buried in the street and at no great depth, very much like the wires in London, in pipes, not far below the surface. The German military telegraph is of another kind. That is the Siemens cable strongly wound with an armor and buried without any other protection directly in the ground. The telephone wires are very abundant in Berlin over the housetops. There is quite a tangle of them, as you will see by many photographs here. I should add that in Brussels perhaps the most remarkable display of wires anywhere is shown by that photograph. (Showing a photograph.) It is a fine picture of their chief cathedral, with wires spread above and running a long distance to their support. In Berlin the housetop fixtures are really very extensive. I never have seen any in New York which were able to carry as many wires at once as those of Berlin. As the government controls the placing of the wires, they are frequently placed on their best buildings, and some of the very fine views across their favorite avenues show these light iron fixtures on top of public buildings. The difference between the German service and that of Belgium is that in Germany the householder must submit to having the fixtures put on his house. He is paid, however, for the service. In Belgium they make the best terms they can, and the telephone companies pay at about the rate of ten cents per wire per year for the use of the housetop.

One picture represents Turin, where there is a great assemblage of wires coming over the housetops. In Brussels one difficulty which Mr. DeGroof said he had experienced was from the disturbance of the wires by angry citizens. The wires were so thick that they killed a great many carrier pigeons. Owners of pigeons would get angry and go up on the housetops and cut the wires. Fifty wires were interruped the day before. An old lady who owned a number of pigeons had cut them down. Cologne has, I think, about fifty—it was August, 1886, that I was there—and Frankfort about four hundred. Four, five or six hundred is about the number for those cities in central Europe.

In Paris a different condition prevailed. I went directly to the electrician. I had letters from Mr. Edison and Mr. Vail introducing me to M. Berthon, in whose charge are all the telephone lines of France. I asked him immediately about his underground system in the sewers. He said, "Yes, they are in the sewers, but they are there because the sewers are right at hand." I asked him "What do you do when you come to the end of your sewers?" He said, "Then we come out and go to the housetops." A little later he showed me a wire drawn out of a sewer—drawn right up, fastened to the side and drawn up to the house where it is wanted. I asked him what was the plan in other French cities. He said they were all on the housetops except in Bordeaux, where about three hundred subscribers are furnished by a system drawn through iron pipes, but they were not doing very well. Then I asked about the electric arc lights. I visited the sewers and walked along through them some distance. I noticed the method of attaching. It was a little hook with a shank, driven into the wall overhead; I could just reach them with my hand. That would hold four or five cables as large as my thumb. There would be twelve or fourteen of those small cables in a single one of these sewers. It was easy to make out the distance of these cables as they branched off, because the sewers are very conveniently marked—the street corners are marked with the name of the streets. In regard to

the arc lighting I asked him if he would put the arc light wires in the same sewers with his telephone wires and he said, "No," very energetically—he would not have them there; indeed he did not believe that arc lighting was going to prevail to any great extent, and then added, "We have less now in this avenue that you are in than we had three or four years ago; we have replaced the arc lights with the gas lights." The gas lights are in groups, five or six burners in each lamp. There were no arc light wires underground, so far as he knew. I noticed while walking with him along the street that there were some wires overhead. He said those were some of the dead wires not yet removed; but he called the superintendent who was in sight, and submitted the question to him. The superintendent said no, that the wires were overhead as there was no sewer in the street: it was a little street. Then M. Berthon added, "There are one hundred subscribers served that way," and again the superintendent interposed to say that there were two hundred in Paris served over housetops solely. He added that in regard to the service that he expected to be able to extend through Spanish cities, it was a franchise that he was expecting to control very soon, but he had made it a condition that he should be allowed to go on housetops. So I got but little information with regard to the best way of burying wires until I got back to England, when, after a short stay and another consultation with the electricians there, I went on to Newcastle. I was assured that they were beginning to put wires underground in Manchester If I went there I should see that they were burying a cable in an iron pipe. Newcastle enjoys the reputation of having all its wires underground. They have a system of iron pipes. They serve some three hundred or four hundred telephone subscribers by the use of the wires. They are controlled by the government. They do not study economy in the method of hauling in wires or in the use of them. They twist their wires together so as to establish a metallic circuit and run from their central station to their customers. I had got this estimate both from M. Berthon and Mr. Preece that when the underground system was fully at work with cables the best that they knew how to make, the limit of service would be about ten or eleven miles underground. I asked if it would be profitable to run further than that if you come out of the ground at that distance. They said that was doubtful; it was a question not solved. M. Berthon stated about twelve miles as the limit at which it was possible to send a telephone message through anything buried in the ground. I mentioned that to the electrician who was assigned to me by Mr. Heaviside, the head of the telephone service in Newcastle, and he said: "I cannot quite accept that estimate, and I think I will give you an opportunity to refute it." So he connected up a line for me to experiment with which he said was a line of twelve and a half miles of cable—what he called cable, that is a lot of wires twisted together in pairs, twisted a little way in one direction and then twisted in the opposite direction. These pairs were put together until there would be about a dozen or twenty, and then they were pulled loosely through the iron pipe. At the end of the twelve and a half miles the wire came out of the ground and connected for about 38 miles further. It was 50 miles and a fraction through which, he said, the telephone service extended. I could converse through that, though I found difficulty where an expert worker at the telephone would not. I could converse through that when the conditions were exceptionally favorable. It was in a padded room and the instrument was in perfect working condition. I had no difficulty in conversing through that twelve and a half miles of cable and the aerial line up to fifty miles. Such telephone service as they have in Newcastle would hardly answer the purpose where there are so many users as we have here. I asked how they increased the number if they had any additional subscribers—how could they pull more wires into the iron pipe that had a twisted tangle of wires already in it. He said they pulled the whole bundle out and sent them to headquarters—the postal department—and they furnished them a new lot. Economy was not considered. He said the government owned the whole thing.

Mr. J. A. Powers—As an operator of a central station lighting plant, I would like to ask what is the longest time—if there are any arc light wires buried underground—what is the longest time during which such wires have been buried up to the present time.

Professor Plympton—I cannot tell that. We have had no experience of that kind in Brooklyn. The arc light company appears to be ready to try experiments when they see their way clearly. We have been more interested in getting the telephone wires underground because they out-number all the others.

Mr. Powers—There seems to be in this matter a very grave misunderstanding by the public as to the danger of the electric light wires themselves. I have kept close watch of this matter since there has been some agitation of the underground question at Troy. I have kept close track of the accidents recently, and I have noticed that four out of five do not occur from the electric light wires directly, but from the coming down on the electric light wire of abandoned wires overhead. The nuisance has become so great in Troy that an ordinance was recently passed by the common council requiring the city engineer to remove those wires, and there is now a mutual action of the telephone, telegraph and electric light companies to see to the removal of "dead" wires. We had one accident a short time since. An abandoned Atlantic and Pacific telegraph wire fell down across us and killed a horse, through no prime fault of the electric light company. If we can get the telegraph and telephone wires underground, which seems to be possible, we shall have, if the recent accidents are any criterion by which to judge, four-fifths of the danger removed at once, and I think that the question of danger will then sink into comparative insignificance.

Mr. Mailloux—I would like to ask Professor Plympton if he can tell us about the working of the underground system at Chicago? I believe the underground system has been working there on a considerable scale.

Professor Plympton—I visited Chicago, and was very politely received by Mr. Barrett, who is superintendent of the work there. He said that he began by forming an agreement with various companies that they should bury their wires as fast as he buried the wires of the city. He is city electrician. He allowed the companies to select their own conduits, so that each company has its own. They have telephone wires, telegraph wires, underground electric light wires for some purposes. There is no municipal street lighting in Chicago, or was not a year ago last February. Some theatres and buildings are lighted, but they run through conduits. That was the case where one of these took fire. I wrote to Mr. Fay and asked about the telephone service, to learn if they had suffered from induction from proximity to any of these other wires. They had in some cases. The harmonic system of telegraphy had created some difficulty through its induction, and there had been complaints, but inasmuch as each company had selected its own conduit and buried its wires in its own way, there was not much to gather about a general system of burying, of getting them into as compact shape as could be done. Indeed, standing at one of the street corners one of the electricians pointed out to me fifteen man-hole covers in sight at the junction of two streets, all within a radius of less than sixty feet. They have there a short way of making connection. Their soil is soft, light sand. They take a sharp pointed pipe and drive that pipe right across the street if they want to make a house connection. It may turn out in the middle of the track and then they pull the pipe out and start again.

In regard to getting information from other sources, the remark made by Mr. Parish in London was significant. He said, "If I had been asked about the best place to go to to learn about underground systems I should have said the United States. We haven't got any here." I found that to be the case. They can come here to learn about underground systems. They cannot overtake our rapid development.

The next paper read was on "The Patent Court and Uniformity in Patent Practice," by Mr. George H. Stockbridge. (See p. 257.)

Mr. Stockbridge preceded his reading by saying: You will remember that some time ago Mr. Steuart, representing the National Electric Light Association, read a paper before you in which he pointed out certain reforms that were regarded as necessary by that association, and there was, I believe, a discussion here of the reforms that were pointed out at that time. I believe it was the design of the association to present bills to Congress embodying the reforms suggested by Mr. Steuart, and embodying them in a revision of the patent law. That scheme, however, met with opposition from some, and instead of that, two bills were presented by the association to Congress, and one of them provides that a patent court be established to have appellate jurisdiction from the Commissioner of Patents in all rejected cases, and the other is that the Commissioner of Patents receive a salary of $8,000. Mr. Steuart asked me to prepare an argument to be submitted to the judiciary committee before whom the bill on the patent court now is, and I prepared such an argument, taking rather a narrow point of view, so as not to interfere with the arguments that were to be made by the other parties.

Professor Nichols then read a paper on "The Swinging Arm Galvanometer." (See p. 259.)

The chairman read the communication from the secretary of the Electric Club, which had been presented at the annual meeting on the previous day, inviting members of the Institute to visit the club house.

The next meeting of the Institute will take place on June 19th, when Mr. F. J. Sprague will read a paper on "The Engineering Problems of Electric Railway Work."

Adjourned.

THE EDISON ELECTRIC LIGHTING COMPANY DEFEATED IN A PATENT SUIT.

United States Circuit Court.—Southern District of New York.

THE EDISON ELECTRIC LIGHT CO. *vs.* UNITED STATES ELECTRIC LIGHTING CO.

OPINION OF JUDGE WALLACE SUSTAINING DEFENDANT'S PLEA.

WALLACE, *J.:*

The plea to the bill of complaint, which has been set down for argument, alleges in substance that the defendant should not be compelled to answer, because by reason of the facts averred in the

plea the remedy of the complainant is plain, adequate and complete at law, and this court should not take cognizance in equity of the suit.

The bill alleges the infringement by the defendant of letters patent of the United States, No. 263,140, dated August 22, 1882, granted to the complainant upon the application of Edison for an improvement in dynamo-electric machines, the invention of Edison. The bill shows that Edison made his application for a patent August 9, 1880, and assigned his title to the complainant June 21, 1881. Besides the averments usually contained in bills to restrain infringement of patents, allegations are introduced by way of anticipation of the supposed defense to the bill in order to meet any issue tendered by the defendants. These averments are in substance that the defendant may wrongfully pretend as an excuse for its wrongful acts in the premises that the complainant's letters patent are no longer in force or operative, because at the time they were granted, the invention described therein had been first patented in the Austro-Hungarian empire for the term of one year, and that such foreign patent has expired, and consequently that the term of complainant's patent has expired; but that the facts are that Edison at the time of making the invention was and always since has been a resident and citizen of the United States, and made, perfected and reduced the invention to practice in the United States, and made and filed his application for a patent in the United States Patent Office, August 9, 1880, and prior to any application made by him abroad, and that in order to protect his invention in foreign countries it was necessary that he should promptly apply for letters patent abroad, and the issue of the foreign patent preceded the United States patent solely because of the greater diligence and more prompt procedure of the foreign administration. The bill further avers that the letters patent of the Austro-Hungarian empire were granted for the term of 15 years from their date, and are in full force and effect.

The plea alleges that prior to the granting of the complainant's letters patent the invention or discovery described and claimed therein had been patented by Edison, or with his knowledge, consent and procurement, by a public patent of the Austro-Hungarian empire, granted to Edison July 21, 1881; that the term for which the foreign patent was granted was one year from its date, and expired on the 21st day of July, 1882; that subsequently, by grant made on the 19th day of July, 1882, the foreign patent was extended for a new term of one year, and the extended term expired on the 21st day of July, 1883; and that the extended Austro-Hungarian patent was existing and unexpired when the complainant's letters patent were granted, but the term thereof expired July 21, 1883, and before the commencement of this suit. The plea denies the averments of the bill that the Austro-Hungarian patent was granted for the term of 15 years, and was in full force and effect when this suit was brought.

If the complainant's patent had expired before the bringing of this suit, it is plain that a court of equity has no jurisdiction of the cause of action for infringement, and the complainant can only proceed by a suit at law for the recovery of damages (Root *vs.* Railway Co., 105 U. S., 189).

It is contended for the complainant that such a defense cannot be raised by a plea, and if it could, that the present plea is insufficient both in matters of form and substance to present such a defense.

One of the uses of a plea in suits at law or in chancery is to object to the jurisdiction of the court (Livingston *vs.* Story, 11 Pet., 351; Wickliffe *vs.* Owing, 17 Howd., 47, 51). In a case where it was urged that the sum involved was not of sufficient amount to authorize a court of chancery to take cognizance of the cause, Chancellor Walworth said: "If that fact did not appear upon the face of the bill, it might undoubtedly have been pleaded in bar of relief." (Smets *vs.* Williams, 4 Paige, 364.)

In Beames on Pleas, 55, it is stated: "Those pleas which are commonly called pleas to jurisdiction do not proceed the length of disputing the right of a plaintiff in the subject of the suit, or allege any disability on the part of the plaintiff to prosecute the suit, but simply assert that a court of chancery is not the proper court to take cognizance of those rights." The present plea falls within this definition.

There is no force in the objection that the plea is a negative plea. Such pleas are sanctioned and are now frequently resorted to. A familiar instance is a plea denying partnership, where the bill prays an account of partnership transactions.

The present plea is not strictly a negative plea. It is a negative plea so far as it denies the averments of the bill that the term of the Austro-Hungarian patent is for 15 years and that the patent was in full force when the suit was brought. It is an affirmative plea as to all the other facts which it sets forth. The effect of the plea is to admit all the facts alleged in the bill except those specifically denied, and to meet the case made by the bill by alleging the new facts intended to show that the complainant's patent had expired at the time of the commencement of the suit. If the bill did not contain the anticipatory averments which have been inserted in it the denial in the plea would have been unnecessary. With this denial in the plea it is only necessary to inquire whether the facts set up affirmatively are a defense to the suit, admitting that everything in the bill not denied is true.

A pleading is sufficient which sets forth documents according to their tenor or legal effect, and avers the substantive facts relied on as a cause of action or defense. Tested by this rule, the plea is sufficient in form without making a profert of the Austro-Hungarian patent, or setting out in detail any of the evidential facts to show that it was a valid grant of letters patent for the invention for the term of one year. If issue were taken on the plea, it would only be necessary for the defendant to produce a properly authenticated copy of the foreign patent and show the seal or signature affixed to it to be the act of an officer duly authorized to issue patents. The effect and operation of the patent is to be determined as a question of law by the terms of the document, unless evidence of the foreign law is introduced to qualify or controvert the construction which would otherwise be placed upon the instrument. It is not necessary in a pleading to allege that an instrument was executed by an agent and that the agent was duly authorized thereto; it is sufficient to allege its execution by the principal. (Delafield *vs.* Kinney, 24 Wend., 345.) The tribunals of every nation take judicial notice of the public seals of sovereign states (1 Greenleaf Ev., Sec. 4); and the annexation of the seal will be presumed to have been made by a person having custody thereof and competent to do the act (Phillips Ev., 419).

The plea sets forth a sufficient defense if the term of a United States patent ends at the same time the term of a foreign patent granted for the same invention ends. when it appears that the foreign patent was not applied for until after the domestic patent was applied for; that it was not applied for by the inventor himself, but by some other person by his procurement, and that the domestic patent was granted to one who at the time of the application was an American citizen and had made and reduced his invention to practice in this country. The question presented depends upon the meaning and effect of section 4,887 United States Revised Statutes, which is as follows:

"No person shall be debarred from receiving a patent for his invention or discovery, nor shall any patent be declared invalid by reason of its having been first patented or caused to be patented in a foreign country, unless the same has been introduced into public use in the United States for more than two years prior to the application. But every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one, at the same time with the one having the shortest term, and in no case shall it be in force more than 17 years."

It is not at all material whether the foreign patent is granted to the inventor who makes the application in this country or to some other person to whom he has caused the invention to be patented; the statute expressly covers both cases. Nor is the fact of any importance that the inventor who makes the application in this country is one of our own citizens; because since the act of July 4, 1836, which repealed all former patent laws and established a comprehensive code covering the whole subject, our laws have not made any distinction between our own citizens and foreigners in respect to the privilege of obtaining patents or the conditions and restrictions of the privilege granted, except as to the amount of the fee to be paid and the protection of inventions by caveat. The question may, therefore, be simplified by eliminating these immaterial ingredients; and the real inquiry is, whether the section limits the term of a domestic patent to the term of a foreign patent when the application for the foreign patent is not made until subsequent to the application in this country, but the foreign patent issues before the domestic patent.

If it were proper to treat this question as an original one, it would be necessary first to inquire whether there is any ambiguity in the language of the statute. If there is not, the duty of the court is to give effect to its obvious meaning, notwithstanding it may be thought to make an unreasonable and harsh innovation upon the pre-existing privileges of our own inventors. It is not only the safer course to adhere to the words of a statute construed in their ordinary import, instead of entering into any inquiry as to the supposed intention of Congress, but it is the imperative duty of the court to do so. Where the meaning of the Revised Statutes is plain the court cannot look to the sources of the revision to ascertain whether errors have or have not been committed by the revisers. (United States *vs.* Boyd, 100 U. S., 508.)

There is no practical difference in the phraseology of section 4,887, and that of section 25 of the act of July 8, 1870, from which the section is reproduced. The precise point now raised by the complainant, but made with reference to the effect of section 25 of the act of 1870, was considered by this court in the Gramme Electrical Co. *vs.* The Arnoux & Hochhausen Electric Co., 21 Blatch., 360. It was insisted by the defendant in that case that the complainant's patent expired at the date of the expiration of an Austrian patent, and the complainant took the position that the defense was not tenable because the application for his United States patent was filed before the application for the Austrian patent was made. It was held by Blatchford, *J.*, that the date of the application for the United States patent could not affect the question, and that the meaning of the statute was that the United States patent should expire at the time of expiration of the foreign

patent, irrespective of the time when the foreign patent was applied for.

Judge Blatchford adopted in that case the views of Judge Nixon upon the same question in Bate Refrigerating Co. *vs.* Gillett, 13 Fed. Rep., 553. In the Bate case the question arose under section 4,887, and it was contended that complainant's United States patent did not expire at the date of the expiration of a Canadian patent, because the application for his patent was filed antecedent to the application for the grant of the Canadian patent. The court was of the opinion that it would be wresting the language of the section from its plain and obvious meaning to sustain that position. These decisions have been followed by Bradley, *J.*, upon a subsequent hearing in the Bate case, and by Colt, *J.*, in Bate Co. *vs.* Hammond (First Circuit U. S.).

In view of these adjudications the question should not be considered as an original one. The plea is therefore allowed.

(A copy.)

[L. S.] JOHN A. SHIELDS, *Clerk.*

John C. Tomlinson, Richard N. Dyer, William M. Evarts and *Clarence A. Seward*, for the plaintiff.

Samuel A. Duncan, Leonard E. Curtis, Frederic H. Betts and *Edmund Wetmore*, for the defendant.

THE PHONOGRAPH.

Mr. Edison's improved phonograph was exhibited at the Electric Club House, New York, on the evening of May 12th, before a large audience of club members and their friends. The phonograph was presented by Mr. E. T. Gilliland, in an address, during which he recited some of the steps through which Mr. Edison has developed the instrument as placed before the audience. Mr. Gilliland has been intimately associated with Mr Edison in his experimental work for some years, during which he has given much attention to improving the details of the phonograph.

Mr. Gilliland was followed by Professor Spice, who set forth a few of the acoustic principles involved in the operation of the phonograph, illustrating them by a short series of very effective experiments.

An opportunity was then afforded to every one present to examine and try the phonograph. One was placed in nearly every room in the capacious club house, in charge of Mr. Gilliland's assistants, who courteously and patiently assisted all comers to use the instrument and learn for themselves its powers.

Much improvement has been effected in the apparatus since the phonograph exhibitions of 10 years ago. The improvement is less noticeable in the reproduction of music and set speeches from the platform to the audience, than in the individual use of the phonograph, with its listening tubes, in reproducing ordinary conversation. The gain here has unquestionably been very great.

Though the phonograph may still be thought to come short of a service sufficiently trustworthy and uniform for a considerable commercial use—the startling distinctness with which it sometimes reproduces human speech, indicates that its entire success is but a question of refinement in the apparatus.

Gen. W. T. Sherman, Col. Robert G. Ingersoll, Allen Thorndike Rice, Esq., and other gentlemen of prominence, were among the guests of the Electric Club.

INTENSITY AND CONSUMPTION OF DIFFERENT SOURCES OF LIGHT.

The following are the results of careful measurements; the unit being a standard English candle. The tables are summarized.

PETROLEUM LAMPS.

A number of different lamps were used. The general result was that all the forms had about the same efficiency. The consumption of oil is about 4.5 gramme per candle-power per hour.

Gas burners.	Candle-power mean.	Cubic feet per candle-power per hour, mean.
Ordinary fishtail	17.	.523
Argand	20.5	.410
Auer's incandescent	12.5	.290
Siemens' regenerative, No. 3	66.	.260
" " No. 1	172.	.350
Wenham, No. 2	40.	.230
" No. 4	181.	.160

The argand burner is better than the fishtail; the latter uses nine cubic feet per hour instead of five or six, as is usually calculated, although this is largely a matter of local condition. The Auer incandescent lamp uses only half the gas that the fishtail consumes, but the deterioration of the incandescent material must be added. Of the high candle-power lamps, the Wenham is most economical.

ARC LAMPS (ELECTRIC).

	Mean candles.	Mean candles per horse-power.
Piefer	250	900
Piette-Krizik	820	1,090
Siemens	2,200	1,330

INCANDESCENT LAMPS.

	Mean candles.	Mean candles per horse-power.
Edison (old type)	16	122
" (new type)	16	147
Swan (old type)	16	133
" (new type)	16	157
Siemens	16	169
Bernstein	16	157

MAGNESIUM LAMPS.

These consist of a small clock-work which gradually unrolls the magnesium ribbon, and advances it through the centre of a reflector at a rate which can be regulated to equal that of consumption. From one to eight ribbons can be used. A ventilator is provided for the escape of the fumes produced by the combustion of the metal. The price of the ribbon is nearly five dollars a pound, and this will make the price of 100 candles per hour 16 cents. This lamp can be improved, and the price of magnesium will probably fall.—*Science*

No. of ribbons.	Candles.	Consumption per hour per ribbon for 100 c.-p.
1	3,200	11.14 grams.
2	5,880	14.10 "
4	8,000	14.80 "
6	11,300	14.15 "
8	17,000	14.03 "

POINTERS.

.... THE maintenance account of a plant often defeats dividends.—*William Lee Church.*

.... THE progress of the future will be more and more towards central station lighting.—*J. N. Shoolbred.*

.... THE cost of the best overhead line for an electric railway is about one-tenth the cost of a conduit.—*R. W. Blackwell.*

... WHAT possible avail can it be, if the right thing is not done in the right way, by the right man and at the right time.—*Thomas D. Lockwood.*

.... WHEN we remember that for the price of two horses, and for the working lifetime of two horses, we can work tramcars by electricity; then when we think that it takes 12 horses, the mere question of £. s. d. will carry the day.—*William H. Preece.*

.... COMPARED with the two-wire system, the three-wire system would save about 12 per cent. of the electrical power, with a proportionate saving in the cost of engines and dynamos. It would also effect a considerable saving in the cost of conductors.—*Dr. John Hopkinson.*

.... THE system which offers the highest commercial efficiency will eventually survive against all competitors. The direct system of electrical distribution from the dynamo to the lamp is the only one by which the highest economy and the largest earning capacity can be obtained.—*Thomas A. Edison.*

.... THE hundreds of millions of dollars already invested in the now antiquated systems and wires, will be as much out of place, for all long distance and bulky matter, after the introduction of siliconized copper wires, and the machine system of telegraphing, as an ox-team on a dirt road competing against a steam engine on a well-appointed railway.—*D. H. Craig.*

.... WERE it not for the cost of the dynamos and motors, electricity would supersede to a great extent the use of belts and shafting. . . . . With electricity, the percentage of power lost in the transmitting medium becomes smaller as the amount of power transmitted is reduced, which is exactly the converse of what happens with belting and shafting.—*William Giessel.*

.... THE magnitude of the commercial interests which have been called into being by physical discoveries and the development of new ideas, indicates that if the progress of the past few years is to continue—if new achievements are to rival those of the past, it must be by a higher education and training, not of a few men, but of the many, so that no germ of talent shall miss its opportunity for development and its chance for increasing the powers and resources of man.—*Chauncey Smith.*

THE HEATING EFFECTS OF ELECTRIC CURRENTS.[1]

I have taken a great deal of pains to verify the dimensions of the currents as detailed in my paper read on December 22d, 1887, required to fuse different wires of such thicknesses that the law

$$C = ad^{3/2}$$

is strictly followed; and I submit the following as the final values of the constant "a" for the different metals:—

	Inches.	Centimeters.	Millimeters.
Copper	10,244	2,530	80.0
Aluminum	7,585	1,873	59.2
Platinum	5,172	1,277	40.4
German silver	5,230	1,292	40.8
Platinoid	4,750	1,173	37.1
Iron	3,148	777.4	24.6
Tin	1,642	405.5	12.8
Alloy (lead and tin 2 to 1)	1,318	325.5	10.3
Lead	1,379	340.6	10.8

With these constants I have calculated the two tables given below, which I hope will be found of some use and value.

wire which had fallen across the electric light wire. The amount paid was $3,500.

On May 14th, the Supreme Court of the United States denied the motion for a rehearing of the Bell telephone case, the motion having been made by the counsel for the People's (Drawbaugh) Telephone Co.

The telephone strike at Rochester, N. Y., which was inaugurated November 20, 1886, has been ended, and the people of Rochester will again enjoy the benefits of a telephone service, of which they were deprived by their own acts. A compromise has been effected, the telephone company agreeing to abandon the "toll system," the proposed adoption of which was the principal cause of the strike, and the subscribers are to pay a "flat" rate somewhat higher than that formerly charged.

.... THE position of a fireman may be considered an humble one by some folks, but he is a man for all that, and his pride in what he can do is a stronger spur than anything else. . . . . But eventually you must pay him what he is worth. If not, someone else will be glad to have him.—*Jarvis B. Edson.*

Table showing the current in amperes required to fuse wires of various sizes and materials.

$$C = ad^{3/2}.$$

No. S. W. G.	Diameter. Inches.	$d^{3/2}$.	Copper. $a = 10,244$	Aluminum. $a = 7,585$.	Platinum. $a = 5,172$.	Ger. silver. $a = 5,230$.	Platinoid. $a = 4,750$.	Iron. $a = 3,148$.	Tin. $a = 1,642$.	Tin lead alloy. $a = 1,318$.	Lead. $a = 1,379$.
14	0.080	0.022627	231.8	171.6	117.0	118.3	107.5	71.22	37.15	29.82	31.20
16	0.064	0.016191	165.8	122.8	83.73	84.68	76.90	50.96	26.58	21.34	22.32
18	0.048	0.010516	107.7	79.75	54.37	54.99	49.95	33.10	17.27	13.86	14 50
20	0.036	0.006831	69.97	51.81	35.33	35.72	32.44	21.50	11.22	9.002	9.419
22	0.028	0.004685	48.09	35.53	24.23	24.50	22.25	14.75	7.692	6.175	6.461
24	0.022	0.003263	33.43	24.75	16.88	17.06	15.50	10.27	5.357	4.300	4.499
26	0.018	0.002415	24.74	18.32	12.49	12.63	11.47	7.602	3.965	3.183	3.330
28	0.0148	0.001801	18.44	13.66	9.311	9.416	8.552	5.667	2.956	2.373	2.483
30	0.0124	0.001381	14.15	10.47	7.142	7.222	6.559	4.347	2.267	1.820	1.904
32	0.0108	0.001122	11.50	8.512	5.805	5.870	5.330	3.533	1.843	1.479	1.548

Table giving the diameters of wires of various materials which will be fused by a current of given strength.

$$d = \left(\frac{C}{a}\right)^{2/3}$$

Current in amperes.	Diameter in inches.								
	Copper. $a = 10,244$.	Aluminum. $a = 7,585$.	Platinum. $a = 5,172$.	Ger. silver. $a = 5,230$.	Platinoid. $a = 4,750$.	Iron. $a = 3,148$.	Tin. $a = 1,642$	Tin lead alloy $a = 1,318$.	Lead. $a = 1,379$.
1	0.0021	0.0026	0.0033	0.0033	0.0035	0.0047	0.0072	0.0083	0.0081
2	0.0034	0.0041	0.0053	0.0053	0.0056	0.0074	0.0113	0.0132	0.0128
3	0.0044	0.0054	0.0070	0.0069	0.0074	0.0097	0.0149	0 0173	0.0168
4	0.0053	0.0065	0.0084	0.0084	0.0089	0.0117	0.0181	0.0210	0.0203
5	0.0062	0.0076	0.0098	0.0097	0.0104	0.0136	0.0210	0.0243	0.0236
10	0.0098	0.0120	0.0155	0.0154	0.0164	0.0216	0.0334	0.0386	0.0375
15	0.0129	0.0158	0.0203	0.0202	0.0215	0.0283	0.0437	0.0506	0.0491
20	0.0156	0.0191	0.0246	0.0245	0.0261	0.0343	0.0529	0.0613	0.0595
25	0.0181	0.0222	0.0286	0.0284	0.0303	0.0398	0.0614	0.0711	0.0690
30	0.0205	0.0250	0.0323	0.0320	0.0342	0.0450	0.0694	0.0803	0.0779
35	0.0227	0.0277	0.0358	0.0356	0.0379	0.0498	0.0769	0.0890	0.0864
40	0.0248	0.0303	0.0391	0.0388	0.0414	0.0545	0.0840	0.0973	0.0944
45	0.0268	0.0328	0.0423	0.0420	0.0448	0.0589	0.0909	0.1052	0.1021
50	0.0288	0.0352	0.0454	0.0450	0.0480	0.0632	0.0975	0.1129	0.1095
60	0.0325	0.0397	0.0513	0.0509	0.0542	0.0714	0.1101	0.1275	0.1237
70	0.0360	0.0440	0.0568	0.0564	0.0601	0.0791	0.1220	0.1418	0.1371
80	0.0394	0.0481	0.0621	0.0616	0.0657	0.0864	0.1334	0.1544	0.1499
90	0.0426	0.0520	0.0672	0.0667	0.0711	0.0935	0.1443	0.1671	0.1621
100	0.0457	0.0558	0.0720	0.0715	0.0762	0.1003	0.1548	0.1792	0.1739
120	0.0516	0.0630	0.0814	0.0808	0.0861	0.1133	0.1748	0.2024	0.1964
140	0.0572	0.0698	0.0902	0.0895	0.0954	0.1255	0.1937	0.2243	0.2176
160	0.0625	0.0763	0.0986	0.0978	0.1043	0.1372	0.2118	0.2452	0.2379
180	0.0676	0.0826	0.1066	0.1058	0.1128	0.1484	0.2291	0.2652	0.2578
200	0.0725	0.0886	0.1144	0.1135	0.1210	0.1592	0.2457	0.2845	0.2760
225	0.0784	0.0958	0.1237	0.1228	0.1309	0.1722	0.2658	0.3077	0.2986
250	0.0841	0.1028	0.1327	0.1317	0.1404	0.1848	0.2851	0.3301	0.3203
275	0.0897	0.1095	0.1414	0.1404	0.1497	0.1969	0.3038	0.3518	0.3413
300	0.0950	0.1161	0.1498	0 1487	0.1586	0.2086	0.3220	0.3728	0.3617

THE TELEPHONE.

Judge Don A. Pardee, of the United States Circuit Court, at New Orleans, recently rendered a decision on final hearing in the case of the American Bell Telephone Co. et al., *vs.* the National Improved Telephone Co., in equity. The court decides that the telephones used by the defendants are an infringement on the Bell patents, and orders that all such instruments be delivered to the clerk of the court, subject to further orders, and gives the complainants judgment against the defendants for all costs, charges and disbursements in this suit. William Grant is appointed master to ascertain costs and damages.

The Bell Telephone Co., of Buffalo, N. Y., has settled with the heirs of James F. Norton, the colored man who was killed some ten weeks ago while attempting to rescue a horse from a telephone

1. W. H. Preece, in *Industries.*

AN INTERESTING PATENT SUIT—DOUBLE CARBON ARC LAMPS.

The suit commenced recently in the United States Circuit Court at Chicago, by George H. Seeley and others against the Brush Electric Co., and another for alleged infringement of the patent of Matthias Day, 1874, on arc lamps will be watched with much interest, and perhaps some concern, by arc lamp manufacturers. Claim 1 of Day's patent is as follows: "In an electric light the combination with each electrode holder and one electrical circuit of two or more electrodes substantially as and for the purpose set forth."

The Western Electric Co., of Chicago and New York, are owners of an undivided half interest in the Day patent and take a leading part in prosecuting the present suit. The joint owners of the patent ask for an accounting and an injunction against the defendant company.

ELECTRIC LIGHT AND POWER.

In the United States Circuit Court, in New York, Judge Wallace rendered an important decision recently in favor of the defendants in 26 suits for infringement of patents brought by the Edison Electric Co. against the United States Electric Lighting Co. The suits were instituted about three years ago and related to certain alleged infringements on patents for incandescent lamps, dynamos and other electric light apparatus. The defendants' counsel took the position that the Edison patents could not be infringed for the reason that they had expired. Judge Wallace allowed this plea to the bills of complainant.

THE suit of the Brush Electric Co. against the Western Electric Light & Power Co., of Toledo, Ohio, for infringement of Mr. Brush's double carbon arc lamp patent of 1879, is still going forward.

AT ELIZABETH, N. J., the arc-lighting system was temporarily disabled by a lightning stroke during the thunder storm of Monday night, May 28th. Every lamp was extinguished.

THE CHICAGO ARC LIGHT AND POWER CO. are now operating one of the most extensive systems in the world—about 1,500 arc lamps being lighted every night. The *Western Electrician*, of Chicago, for May 5th, contains a fully illustrated description of the main station of this company at Washington and Market streets.

REFERRING to a rumor that the Edison company contemplates the raising of the standard voltage of the Edison system from 220 to 330 volts, *The Electrician*, London, says:

"On this point we are enabled to add some further information derived from an independent and thoroughly authentic source. It appears that about twelve months ago several important local companies working the Edison system in America found that they had practically arrived at the end of their tether—that is to say, they had completely covered the ground within the limits of the three-wire 220-volt system, and, unless they could extend the economical radius of distribution, the output could not be further increased. Whether or not they had in all cases arrived at the limit of 20,000 lamps, which Mr. Gordon holds to represent the maximum economical output for a single station, we cannot say, though a maximum current of 9,000 amperes mentioned by our correspondent represents about 36,000 lamps, and might mean nearly 50,000 wired. However this may be, it appears that under the aforesaid circumstances a strong disposition was shown to introduce alternating currents for the supply of the outer circle, and a memorial was presented to the parent company in favor of such a step. But although the movement was strongly supported by several of the leading men connected with the system, Edison himself set his face against it from the first. We may believe that it was this agitation which recently led Edison to rake up his earlier patents with motor-generators, and to lay down the experimental plant of this type, which is now running at Llewellyn Park. We have yet to learn how much success the latter system has attained, but it is tolerably evident that it has not yet emerged from the experimental stage. It is also evident that Edison has succeeded in stemming the movement which had set in amongst his supporters in favor of alternating currents. Probably the enormous increase of business from the transmission of motive power had also a good deal to do with the decision to stand by the continuous current."

ACCORDING to the *Revue Scientifique*, the most advantageous thickness of carbon for arc lamps, taking the currents specified, is given in the following table:—

Current in amperes.	Diameter of carbon in millimeters.
2 to 3	2
3 to 5	4
4 to 6	5
7 to 10	7
10 to 11	9
11 to 15	10
12 to 16	11
13 to 20	12
15 to 21	13
16 to 25	14
25 to 30	15
30 to 45	17
35 to 60	18
40 to 80	20
50 to 120	25
80 to 180	30

For heavy currents, our contemporary recommends bundles of carbon rods of 4mm. diameter or fluted carbon rods.

Foreign.

Austria.—Considerable progress is being made in various Austrian towns with electric lighting. The total number of glow lamps now installed in Vienna may be estimated at eighteen thousand, and in addition there are about one thousand arc lamps in use. One of the most complete installations in Bohemia is that on the Sophieninsel, in Prague, an island on which is a casino used for public entertainments. This installation has been erected by Herr Krizik, and consists of three Otto gas engines, each of 50 h.p., and a small gas engine for starting the big engines. There are four disc dynamos, each capable of supplying four hundred lamps. In the assembly rooms of the casino there are fixed five arc lamps, and nine hundred glow lamps; but as there is current to spare, some street lighting by arc lamps will be done from these dynamos. The whole of the plant for this installation, including the handsome electroliers, has been manufactured and supplied by Herr Krizik, who is also the contractor for the lighting. The light is paid for, not by the amount of current consumed, but by the amount of gas consumed in the engines, the charge varying from 20 kreuzer to 32 kreuzer per cubic meter, according to the number of lamps in use at a time. The gas for the engines costs 9½ kreuzer per cubic meter, or about 4s 9d. per 1,000 cubic feet, so that the contractor for the electric light receives a surplus of about 7s. on every 1,000 feet of gas required, and this covers his profit, the payment of wages, lamp renewals, carbons, and other charges standing against the installation.

Belgium.—The annual report of the administrative council of the Tramway Company of Brussels, states that the working of three cars electrically during 1887, has resulted in a loss of $3,000. The service was commenced on the 17th of April, 1885, with one car running between the Place Royale and the Rue Belliard. A second car was run on the 8th May, and a third on the 19th September. These cars are at present running in the Rue de la Loi. The electric cars covered last year 34,500 miles. The financial failure, although not officially so stated, is thought to be due to the rapid wearing out of the accumulators. The depreciation of these is calculated at 22 centimes per kilometer—or say 6½ cents per car mile; and as this estimate does not allow for general charges, nor for the cost of power, it is evident that the total working expenses must be considerable. The destruction of the plates is ascribed to the continual surging of the acid among them, coupled with the vibration to which the cells are exposed. M. Julien proposes to remedy the defect by placing a number of rubber rings round the plates, the rubbers to act as separators, and at the same time to subdivide the acid into smaller quantities, and so limit the surging action.—*Industries.*

The Molière Theatre at Ixelles, a suburb of Brussels, is entirely lighted by electricity, small glow lamps being used in the auditorium, on the stage, and in the rooms, and an arc lamp being placed in the chandelier. The atmosphere of the house has been much improved since gas was done away with. The price charged for the electric light is the same as was previously paid for gas. The generating plant is placed in the basement at the back of the theatre, a 35 h. p. Meunig engine and two Thomson-Houston dynamos being employed. Steam is supplied from a De Naeyer boiler.

England.—Lords Crawford and Wantage, Sir Coutts Lindsay, and others, have boldly thrown down the gauntlet to the gas people. They have taken ground at Deptford, for a central station, and are going to supply electricity to London. They start with 200,000 lamps, and charge at the same rate as gas at 4s. 2d. per 1,000 cubic feet.

Professors Ayrton and Perry have satisfactorily disposed of the question as to whether there is any difference in the light emitted by a glow-lamp when incandesced by alternate or direct currents. They find no difference. The same power (3.39 watts) applied gives the same light (one candle) in each case.

Germany.—The following relative figures of the cost of the production of 1,000 watt-hours, the unit of electrical energy introduced by the board of trade, are given by Peukert in the *Centralblatt für Electrotechnic*:

	s.	d.
Thermo-electric battery (gas)	33	4
Bunsen battery	3	2
Daniell "	2	2½
Dynamo (gas)	0	6¼
Dynamo (steam)	0	2½

Scotland.—THE BRUSH PLANT AT THE GLASGOW EXHIBITION.—The electric lighting plant of the Glasgow International Exhibition, supplied by the Anglo-American Brush corporation, is said to be the largest ever installed in connection with any exhibition. Nine large boilers drive engines of various kinds, and produce lights equal to over 1,000,000 candles. In the principal structure there are 437 arc lamps of 2,000 candles each, while in the art galleries there are 40, and in the grounds 70 lamps of similar illuminating power. In the dining rooms there will be 750 16 c. p. incandescent lamps.

PERSONAL MENTION.

MR. T. CARPENTER SMITH has resigned his position in the Allegheny County Light Company, of Pittsburgh, Pa., to go into business as one of the firm of M. R. Muckle, Jr. & Co., at No. 608 Chestnut street, Philadelphia, mechanical and electrical engineers and contractors. Mr. Smith has made an enviable record as an electrical engineer, and in his new connection will doubtless find scope for his talents in a more extended field.

MANUFACTURING AND TRADE NOTES.

THE SPRAGUE Co. have just received orders for a number of motors to be shipped to Paris. They report large sales of standard motors for the last two weeks. Mr. F. B. Thurber, of the wholesale grocery house of Thurber, Whyland & Co., New York, expresses entire satisfaction with the elevator service recently installed in their place by the Sprague Electric Railway and Motor Co. The service is regarded as not only good but cheap.

Among orders recently received by the company is one for a large number of motors to be used in the new marble building of A. J. Drexel, Philadelphia. The average power of the motors is about 7½ h.p.

Another order just completing is an installation of electric motors at the "Ophir Farm," White Plains, N. Y., the country residence of Mr. Whitelaw Reid. The motors are to be used for pumping water, stable work, and other purposes.

J. F. BAHR & Co., well known as manufacturers of electrical apparatus, have removed from 108 Liberty street to No. 38 Dey.

MESSRS CHAS. A. SCHIEREN & Co. report recent sales of leather link belting to the following parties, for use on dynamos: Home Electric Light Co., Tyrone, Pa.; Narragansett Electric Light Co., Providence, R. I.; Scranton, Ill. Heat and Power Co., Scranton, Pa.; Thomson-Houston Electric Co., Lynn, Mass.; Sheffield Electric Light Works, Sheffield, Ala.; Circleville Edison Electric Ill. Co., Circleville, O.; Lima Electric Light and Power Co., Lima, O.; Chester Electric Light Co., Chester, Pa.; Virginia Electric Light and Power Co., Richmond, Va.

THE UNION SWITCH AND SIGNAL Co. has made a new departure in the manner of supplying interlocking and signaling apparatus. Heretofore, the company has contracted to supply not only the special parts made at its works, but has contracted to supply the labor to erect the work ready for operation.

The managers of several railroad companies have requested them to bid on material delivered f. o. b. cars, and to furnish competent superintendents of erection, pointing out that they can utilize their ordinary labor for the work of erection, and thus make the total cost much less than it has heretofore averaged.

Hereafter all bids of the company will be for material with superintendence, except when for special reasons the apparatus erected complete, ready for work, is desired. In such cases, two bids will be made, one for the material only, and the other for the erection.

Mr. Henry Snyder has been appointed general manager of this company, succeeding Mr. C. R. Johnson. Mr. E. H. Goodman, who was connected with the Pullman Palace Car Co. for eighteen years, and since August 1886, as second vice-president, has been appointed assistant general manager and general agent.

HOLMES, BOOTH AND HAYDENS, manufacturers of bare and insulated copper wires, issue in very convenient form a pamphlet of note-book size, containing, along with other useful information, a table of maximum safe carrying capacity of bare copper wire, arranged by Mr. H. Ward Leonard, electrical engineer, of Chicago. On the page facing the table Mr. Leonard has placed a chart, with the curve of safe-carrying capacity, the whole making a valuable addition to an electrician's pocket book.

THE STANDARD UNDERGROUND CABLE Co., Pittsburgh, Pa., have issued a new price list (No. 5) of Waring cables, weather-proof line wire, &c. Convenience is afforded to customers by the columns showing approximate feet per pound and approximate weight per 1,000 feet in the list of weather-proof line wire. Important and desirable details are shown in the price list of electric light cables, in which are given first, the B. and S. gauge number and then the diameter of solid copper wire, also the area in circular mils, and the nearest approximate equivalent in Birmingham wire gauge, also the weight per foot of cable and the diameter of the same.

ELECTRIC STREET RAILWAYS IN AMERICA

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horse-power; **T.**, T rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scafe; *Sec.*, Arthur Kennedy; *Supt.*, J. J. Houghton; *Eng.*, Sam'l Drescher; 4 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta. 250 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½: 45 lb.; 3 m. c.; 1 m.; sta. —— h. p.; overhead cond. THOMSON-HOUSTON.

Meriden, Conn.—New Horse R. R.—*Pr.*, T. J. Lathram; *Sec.* and *Tr.*, T. A. Lamb; 5 mi.; g. 4-8½; 35 lb.; 12 m. c.: overhead cond. DAFT.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Supt.*, G. Johnson; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; water-power; overhead cond. THOMSON-HOUSTON.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; 5 mi.; g. 4-8½; 25 and 56 lb.; 3 m. c.; overhead cond. SPRAGUE.

Columbus, O.—Columbus Elect. Ry.—10 mi.; g. 5; 2 m. c.; underground conduit. SHORT.

Denver, Col.—Denver Tramway Co.—*Pr.*, Rodney Curtis; *Sec.*, Wm. G. Evans; *Supt.*, Jno. C. Curtis; 4 mi.; g. 36; 16 and 18 lb.; 10 m. c.; sta. 125 h. p.; conduit cond. SHORT-NESMITH.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g. ——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE. Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; 1 mi.; g. 5-2; 56 lb.; 2 m. c.; sta. 80 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1 c.; 1 m.; sta. —— h. p.; conduit cond. VAN DEPOELE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, Chas. D. Haines; *Sec.* F. H. Skeele; 1.5 mi.; g. 4-8½; 25 lb. T.; 2 m. c.; sta. 50 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Kansas City, Mo.—Kansas City Elect. Ry. Co.—*Pr.*, W. W. Kendall; *Sec.* & *Tr.*, Warren Watson; *Supt.* John C. Henry; 2 mi.; g. 4-8½; 70 lb.; 4 m. c.; sta. 80 h. p.; overhead cond. HENRY.

Lafayette, Ind.—Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2.25 mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 48 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. THOMSON-HOUSTON.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair Ry. Co.—*Pr.*, Theo. Evans; *Sec.*, J. W. Patterson; 2 mi.; g. 5-2½; 45 lb.; 5 c.; 5 m.; sta. 175 h. p.; overhead and conduit cond. DAFT.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt.*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. THOMSON-HOUSTON.

Richmond, Va.—Union Pass. Ry. Co.—*Pr.*, J. T. Brown; *Sec.* and *Treas.*, J. F. Barry, *G. M.*, G. H. Burt; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 375 h. p.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. M. Waugh; 5.75 mi.; g. 4-8½; 30 lb.; 3c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

St. Joseph, Mo.—Union Ry. Co.—*Pr.*, Seymour Jenkins; *Sec.* and *Tr.*, A. Steinacker; *Supt.*, Chas. Wilson; 9½ mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Supt.* B. T. Killam; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 7 m. c.; sta. 360 h. p.; overhead cond. THOMSON-HOUSTON.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond.; THOMSON-HOUSTON.

Wichita, Kas.—Wich. Riverside & Suburban Ry. Co.—*Pr.*, J. O. Davidson; *Sec.*, N. G. Lee; 4 mi.; g. 6-8; 45 lb; 6 m. c.; sta. h. p.; overhead cond.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—7 mi.; g. 5-2; 50 lb.; 3 m. c.; overhead cond. SPRAGUE.

Wilmington, Del.—Front & Union St. Pass. Ry. Co.—*Pr.*, G. W. Bush; *Supt.*, S. W. Price; *Tr.*, E. T. Taylor; 1-3 mi.; g, 5-2; —— lb.; 3 m. c.; overhead cond. SPRAGUE.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.75 mi.; g. 3-6; 35 lb.; 1 c.; 2 m. c.; sta. 20 h. p.; overhead cond. THOMSON HOUSTON.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb. T; 1 m. c.; sta. 1,000 h. p.; overhead cond. THOMSON-HOUSTON.

Constructing or Under Contract.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—6 mi.; g. 4-8½; —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond. SPRAGUE.

Brockton, Mass.—East Side St. Ry. Co.—*Pr.*, A. F. Small; *Sec.*, C. A. Noyes; —— m.; overhead cond. THOMSON-HOUSTON.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown. THOMSON-HOUSTON.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper. DAFT.

Davenport, Iowa.—3.5 mi.; 8 m. c.; overhead cond. SPRAGUE.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. THOMSON HOUSTON.

Elsinore, Cal.—Elsinore Lake Shore Elect Ry. Co.—*Pr.*, D. G. Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.

Erie, Pa.—Erie City Pass. R. R. Co.—*Pr.*, W. W. Reed; *Sec.*, J. L. Sternberg; *Supt.*, Jacob Borst.

Flushing, N. Y.—Flushing & College Point St. R. R.—*Pr.*, J. Dykes; *Sec.*, Arthur Herring; 1 mi.; storage bat's.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; 6 m. c.; overhead cond. SPRAGUE.

Lakeside, O.—3 mi.; 2 c.; overhead cond.

Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi.; g. 4-8½; 56 lb.; 10 m. c.; storage bats.

Louisville, Ky.—Central Pass. R. R. Co.—*Pr.*, B. du Pont; *Sec.*, J. C. Donigan; —— mi; g. 5.

Meriden, Conn.—Meriden Horse R.R. Co.—*Pr.*, Geo. R. Curtis; *Sec.* and *Tr.*, C. L. Rockwell; *Supt.*, D. Barker; 5 mi.; g. 4-8; 35 lb.; 12 m. c. DAFT.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W, Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.
New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*. E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.
New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.
Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.
Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.
Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.
Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, C. D. Haines; *Sec.* & *Tr.* F. H. Skeele; 4-5 mi.; g. 4-8½; 40 lb.; 6 m.; 6 c.;
Revere, Mass.—Lynn & Boston R. R.—Ocean Ave. line; overhead cond. THOMSON-HOUSTON.
Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.
St. Louis, Mo.—Lindell Ry. Co.—*Pr.* J. H. Maxon; *Sec.* and *Tr.* G. W. Baumhoff; —— mi.; g. 4-10; storage bats.
Sacramento, Cal.—Sac. Elect. Ry. Co.
Salem, Mass.—Naumkeag St. Ry. Co.—*Pr.*, C. Odell; *Tr.*, H. Wheatland; —— mi.; g. 4-8½; 6 m. c.; overhead cond. SPRAGUE.
San Jose, Cal.—San Jose Motor Co.—*Pr.*, J. W. Rea.
Sault Ste. Marie, Mich.—S. St. M. St. Ry. Co.—*Pr.*, E. M. Lacy; *Sec.*, F. Ryan; *G. M.*, L. G. Cody; 2 mi. FISHER.
Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.*, A. Frothingham; *G. M.*, B. F. Killam; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; overhead cond. VAN DEPOELE.
South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.
Springfield, Mo.—2 mi. FISHER.
Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.
Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; 3.25 mi.; g. 4-8½; overhead cond. THOMSON-HOUSTON.
Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

Notes.

THE MAIN ELECTRIC MOTOR is to be tried on the Fort Hamilton line of the Brooklyn City Railway Company.

AT COLUMBUS, OHIO, a 250 h.p. plant is being erected, intended to operate fifty street cars on ten miles of double track on the short series system. Charles F. Brush, of Cleveland, is said to be largely interested in this enterprise, and it is understood motors designed by him are to be used.

THE HARTFORD AND WETHERSFIELD RAILWAY COMPANY propose to use electricity on its line.

ELECTRIC RAILWAY enterprises are on foot in the following places:—Hudson, N. Y.; Huntington, W. Va., Montreal, Canada; Modesto, Cal.; St. Augustine, Fla., and Tiffin, O.

THE PEOPLE'S PASSENGER RAILWAY COMPANY, of Philadelphia will place a Wharton electric motor car, 22 feet in length with double trucks, on the 4th and 8th street line.

THE J. G. BRILL COMPANY, of Philadelphia, is building six electric storage battery cars for William Wharton, Jr., and ten for the Fourth avenue line in New York.

ALL the electric railway construction companies report rapidly increasing business in every direction, and important contracts are being closed almost daily. There is little doubt that the mileage of electric railways in the United States will be doubled, if not tripled, before the end of this year.

THE electric equipment furnished by the Sprague Electric Railway and Motor Company to the Richmond Union Passenger Railway has proved to be one of the most successful, as it is the most extensive undertaking of the kind in existence. The topography of the city rendered the project a very difficult one to carry out, and it gives us pleasure to record that the equipment has been accepted by the company, and that its operation is in the highest degree satisfactory. Forty cars are now running from one central station, and the total motive power expenditure, both in the central station and on the road, including depreciation and everything except executive expenses, proves to be only 4.32 cents per car mile. The cars are crowded with passengers, and the financial success of the scheme has been immediate and beyond anticipation.

C. J. VAN DEPOELE is now at the Lynn factory of the Thomson-Houston Electric Company, perfecting the details of electric railway motors.

THE trial trip of the Ansonia Electric Railroad was made April 30th. This is a freight as well as a passenger line, and the result of the experiment of hauling heavy freight cars by electricity will be watched with interest.

IT is reported that the Thomson-Houston Electric Company will introduce its electric conduit system on the line of the West End Street Railway Company between Cambridge and Newton, Mass. President Whitney is making a careful examination of the system.

THE SPRAGUE ELECTRIC RAILWAY AND MOTOR CO. have just moved into their new and capacious offices, 16 and 18 Broad st, N. Y., with increased facilities for the accommodation of their friends and customers.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From April 24 to May 15, 1888 (inclusive).

Alarms and Signals:—*Electric Signaling Apparatus*, M. W. Parrish, 381,576. *Electric Alarm for Ships' Compasses*, A. Gross, 381,698. *Annunciator and Signaling Apparatus*, M. Martin, 381,709. *Electric Bell*, C. F. De Redon, 381,765. *Electric Annunciator*, J. Geary, 381,772. *Electrical Bell or Mechanical Striker*, J. H. Bickford, 381,823. *Electric Fire and Burglar Alarm*, A. Schuchman, 381,852. *Automatic Fire Alarm System*, J. Young, 381,896, April 24. *Fire Alarm Signal Circuit*, W. Carroll, 382.258, May 1. *Electric Burglar-Alarm*, H. C. Roome, 382,439. *Electric Burglar-Alarm*, G. F. Taft, 382,444, May 8. *Automatic Fire-Alarm*, J. Young, 382,788. *Directory Indicator for Buildings, &c.*, T. J. McTighe, 382,997, May 15.

Conductors, Insulators, Supports and Systems:—*Conduit*, J. Steel, 381,653, April 24. *Insulating Joint*, J. T. Robb, 382,272, May 1. *Locking Device for Cable-Splices*, W. R. Patterson, 382,726. *Manufacture of Telegraph Cables*, same, 382,767. *Method of Manufacturing Electric Cables*, same, 382,768. *Underground Conduit for Electric Wires*, W. F. Smith, 382,778. *Insulated Wire*, J. D. Thomas, 382,781. *Telegraph Cable*, W. R. Patterson, 382,829, May 15.

Distribution:—*Transformation and Distribution of Electric Energy*, R Kennedy, 381,794, April 24. *System of Electrical Distribution*, N. Tesla, 381,970. *Electrical Transmission of Power*, same, 382,280, and 382,281. *Method of Converting and Distributing Electric Currents*, same, 382,282, May 1. *System of Electrical Distribution*, T. A. Edison, 382,415, May 8.

Dynamos and Motors:—*Steam Dynamo-Electric Machine*, R. H. Mather, 381,568. *Armature for Dynamos*, M. A. Muller, 381,636. *Electric Motor for Railways*, S. H. Short, 381,650. *Armature for Dynamos*, J. F. Kelly, 381,700. *Regulation of Electric Motors*, S. D. Field, 381,768. *Dynamo-Electric Machine and Motor*, M. Immisch, 381,789, April 24. *Electro-Magnetic Motor*, N. Tesla, 381,968 and 381,969. *Armature for Dynamo-Electric Machines*, R. Mackie, 382,174. *Electro-Magnetic Motor*, N. Tesla, 382,279, May 1. *Alternating-Current Dynamo-Electric Machine*, E. Thomson, 382,335. *Electric Motor for Railway Cars*, W. M. McDougall, 382,483. *Electric Motor*, G. F. Card, 382,589, May 8. *Switch for Electric Motors*, R. H. Mather, 382,714. *Switching Device for Electric Motors*, same, 382,715. *Commutator for Dynamo-Electric Machines*, N. Tesla, 382,845, May 15.

Galvanic Batteries:—*Solution for Voltaic Batteries*, C. E. Egan, 381,542, April 24. *Galvanic Battery*, G. H. Sloane, 382,738, May 15.

Ignition:—*Electric Gas Lighter*, C. W. Holtzer, 382,001. *Electric Igniting Apparatus*, L. Hen and R. Weinmann, 382,231. *Automatic Electric Gas Burner*, E. E. Bailey, 382,249, May 1.

Lamps and Appurtenances:—*Electric Light Carbon*, T. L. Clingham, 381,614, April 24. *Protector for Electric Lamp Sockets*, C. P. Reilly, 382,110, May 1. *Electric Arc Lamp*, R. E. Fenner, 382,421. *Electric Lamp Filament*, C. Seel, 382,560, May 8. *Manufacture of Incandescent Electric Lamps*, E. P. Thompson, 382,846. *Incandescent Lamp Attachment*, H. M. Doubleday, 383,046, May 15.

Measurement:—*Electrical-Measurement Apparatus*, H. V. Hayes, 381,780, April 24.

Medical and Surgical:—*Electro-Medical Apparatus*, P. Horst, 382,811, May 15.

Miscellaneous:—*Electric Door-Opener*, J. Schneider, 381,725. *Electric Indicator*, E. Weston, 381,736. *Heating by Electricity*, E. E. Ries, 381,815. *Electric Heating Apparatus for Railway Cars*, same, 381,816. *Electric Heating System*, same, 381,817. *Method of Electro-Chemical Heating*, same, 381,818. *Electrical Apparatus*, C. C. Sibley, 381,856. *Electrical Method of Automatically Controlling the Supply of Water or Gas*, L. Weil, 381,866, April 24. *Electric Pen-Holder*, C. W. Reitler, 381,953. *Watchman's Time-Detector*, G. B. Fessenden, 381,992 and 381,993. *Method of Signaling at Sea*, D. Ruggles, 382,056. *Automatic Temperature Regulator*, W. S. Johnson, 382,165, May 1. *Switch for Electric Circuits*. C. C. Stirling, 382,332 and 382,333. *Alternatiing Current Regulator*, E. Thomson, 382,336. *Burnishing Attachment for Phonographs*, T. A. Edison, 382,414. *Feed and Return Mechanism for Phonographs*, same, 382,416. *Process of Making Phonogram Blanks*, same, 382,417. *Phonogram Blanks*, same, 382,418. *Process of Duplicating Phonograms*, same, 382,419. *Phonogram Blank*, same, 382,462. *Electric Stop-Motion for Knitting-Machines*, C. Draper, 382,593. *Automatic Electrical Switch*, F. Stitzel, 382,625, May 8. *Coin-Operated Electrical Apparatus*, N. W. Russ, 382,734. *Repeating Induction Coil*, J. A. Barrett, 382,856. *Electric Indicator*, J. Tregoning, 382,914. *Electrical Agricultural System*, E. M. Bentley, 382,941. *Electric Tele-Thermoscope*, H. W. Hardinge, 382,976. *Automatic Shunt for Magneto-Generators*, C. E. Scribner, 383,016, May 15.

Railways and Appliances:—*Electric Railway*, R. M. Hunter, 381,555. *Electric Railway*, same, 381,556. *Trap for Electric Railway Conduits*, W. M Schlesinger, 381,585. *Combined Station Indicator and Signaling Apparatus for Railway-Trains*, J. H. Bickford, 381,669. *Heating Railway-Cars by Electro-Chemical Means*, E. E. Ries, 381,819. *Suspended Cable and Electric Railroad*, G. R. Taylor and W. Heckert, 381,862, April 24. *Pneumatic Railway and Conveyer*, T. A. and A. A. Connolly, 381,907. *Electric Lighting Apparatus for Railroad Cars*, H. E. Dey, 381,915, May 1. *Electric Railway Signal*, B. H. Gedge, 382,299. *Electric Railway Signal*, C. F. DeRedon, 382,515, May 8. *Railway Signal*, C. D. Tisdale. 382,741. *Electro-Magnetic Car-Brake*, A. P. Massey, 382,766. *Electric Railway*, R. M. Hunter, 382,876 and 382,877. *Electrically-Propelled Vehicle*, W. H. Knight, 382,990, May 15.

Storage Batteries:—*Secondary Battery*, A. V. Meserole, 381,941. *Apparatus for Preparing Secondary-Battery Plates*, A. F. Madden, 382,098. *Automatic Switch for Secondary Batteries*, J. S. Sellon, 382,112, May 1. *Plate for Storage Batteries*, C. D. P. Gibson, 382,358. *Secondary Battery*, L. Epstein, 382,420. *Automatic Switch for Secondary Batteries*, C. A. Faure, 382,599, May 8. *Storage Battery*, C. D. P. Gibson, 382,968, May 15

Telegraphs:—*Telegraphic Signaling Apparatus*, J. B. Willis, 381,738. *Telegraphy*, P. B. Delany, 381,764. *Dynamo-Telegraphy*, F. W. Jones, 381,839, April 24. *Telegraph Receiver*, C. Selden, 382,195, May 1.

Telephones, Systems and Apparatus:—*Telephone Receiver*, W. H. Collins, 381,531, April 24. *System of Telephonic Intercommunication*, J. A. McCoy, 381,938, May 1. *Telephone System*, R. N. Dyer, 382,461. *Multiple Switch-Board*, M. G. Kellogg, 382,474, 382,475, 382,476 and 382,477. *Telephone Exchange*, H. H. Eldred, 382,518, May 8. *Mechanical Telephone*, P. L. Mason, 382,713. *Telephone-Exchange System*, C. E. Scribner, 383,013. *Switch-Board*, same, 383,014. *Clearing-Out Annunciator*, C. E. Scribner, 383,015. *Test-Circuit for Telephone Call-Boxes*, same, 383,017. *Key-Board Apparatus for Telephone-Exchanges*, same, 383,018, May 15.

THE
ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS.

PUBLISHED MONTHLY AT

11 Wall Street, New York City.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum, $3.00
Four or more Copies, in Clubs (each)	" 2.50
Great Britain and other Foreign Countries within the Postal Union	" 4.00
Single Copies, -	.30

[*Entered as second class matter at the New York, N. Y., Post Office, April 9, 1888.*]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers*

VOL. VII. NEW YORK, JULY, 1888. No. 79.

By arrangement with the ELECTRICAL WORLD *of New York and with* THE WESTERN ELECTRICIAN *of Chicago, the publishers are enabled to offer either of those weekly journals, together with* THE ELECTRICAL ENGINEER, *for one year to new subscribers for* $5.00, *or the three journals for* $7.50.

THE COMMERCIAL ASPECT OF ELECTRIC LIGHTING.

THE record of litigation in connection with important patents relating to electric lighting, has been, so far as this country is concerned, a singularly disastrous one for their owners. The attempt of Siemens to obtain a patent, which if successful, would virtually have controlled the manufacture of the modern type of dynamo machines, was frustrated by his delay in making application until one of the machines had been two years in use in the United States. The Gramme syndicate were defeated in their efforts to place themselves in a similar position, by reason of the expiration of a prior foreign patent for the invention. The Brush company brought a suit to enforce its patent on the arc lamp, and after a protracted and expensive legal contest, was defeated by the production of evidence of an actual, though limited, prior public use. And now the Edison incandescent lamp patents appear to be doomed to share the fate of their unfortunate predecessors.

As a result of this state of affairs, the public has enjoyed what has been practically an era of unrestricted competition in both arc and incandescent lighting, for some 10 years. But contrary to the general opinion, indications are by no means wanting that the present condition of things is likely to undergo a material change at no distant day. A combination or consolidation of electric lighting interests has often been discussed, and sundry attempts have been made in the past to realize it. But the combined resistance of the innumerable personal interests which would be affected by such a move has been far too great to permit much real progress in the desired direction to be made. Meantime the stockholders of the electric light companies, as well as the public, have gradually become more and more disgusted with the present outlook. Only a very small proportion of the vast sums of money embarked in electric lighting enterprises has yielded any return whatever, and it is becoming painfully evident that the bulk of the investment must sooner or later be charged to the account of "profit and loss." On the other hand the public is badly served; many plants are becoming dilapidated, and the catalogue of disasters to life and property is lengthening with ominous rapidity. There exists in fact, an exact reproduction of the state of affairs which existed in the telegraphic service 30 years ago, and as surely as history repeats itself, so surely the same remedy will be applied, consolidation or union of interests. Such a consolidation will not come voluntarily; it can only be brought about, like the welding of metal, by the combined effects of internal heat and external pressure. Many considerations, some of which are of a commercial and others of a legal nature, indicate that the beginning of the end is not far distant. However well-founded the public antipathy to monopolies may be, it must at least be affirmed of an electric light monopoly, that it is so closely hemmed in by its great rival, gas, that no fear of extortionate charges need agitate the mind of the prospective consumer. But the history of the consolidation of the telegraph interests clearly shows that the real source of future profit lies in the reduction of expenditure and in the increase of the business. Every one knows that the money received in the electric lighting business to-day would yield a very large profit, if all unnecessary expenses were abolished. That the force of circumstances must ultimately bring about the result we have pointed out, in spite of all opposition on the part of persons interested in preventing it, seems to us as certain as any future event can be.

A SERMON FOR THE TIMES.

THE absurd story published in the newspapers a few days since, with the usual pretentious accuracy of detail, to the effect that a woman had been paralyzed by an electric shock while riding in one of the cars of the Brooklyn and Jamaica electric railway, is an example of the senseless prejudice with which the public mind has become saturated in respect to the use of the modern conveniences of life in which electricity is coming to take a prominent part. Everybody has laughed over the story of the destruction of the telegraph lines in Alabama some years ago, by a mob of ignorant and superstitious people, who believed the wires to be the cause of the dry weather which had destroyed their crops and deprived them of their means of subsistence. Yet it is difficult to comprehend wherein the intelligence of the average newspaper editor, or reader, for that matter, is so very much in advance of the "pore white trash" of Alabama in this particular respect.

But, when we undertake to account for this state of affairs, which forebodes an infinite amount of trouble and

expense in the future for electrical enterprises, we are met with the astonishing fact, that it has been sedulously and persistently inculcated by the electrical people themselves, and that as a matter of fact, it is wholly due to what in plain terms must be characterized as the criminal and reckless mendacity which has been indulged in without stint by the short-sighted officials and advertising agents of certain electrical companies, for the purpose of creating prejudice against the systems and apparatus of their business competitors. Of course this silly and senseless policy could have but one effect, that of inspiring the public, which as a rule is incapable of distinguishing dynamos from dynamite, much less one electrical system from another, with an unreasonable and childish terror of all electrical appliances whatsoever.

We might go into particulars and give a long list of offences of this kind, in the way of authorized publications which have been scattered broadcast, and which are filled to repletion with the most barefaced and unblushing falsehoods, misrepresentations and insinuations respecting the systems and apparatus supplied by their business competitors.

We cannot however refrain from particular mention of one publication of this character relating to electric railways, which came into our hands a few days since, and which might well cause Ananias, were he still living, to hang his head for very shame, to think of the vast possibilities in his peculiar line of ability which he never even so much as conceived of. In view of the number, the boldness, and the ingenuity of the lies which bristle from every line—we had almost said every word—of this incomparable production, we must in all kindness advise the authors of "Death in the Air," the "Fire Cracker," and even that recent convert from high-tension heresies, who in the columns of the *Evening Post*, is enlightening the public in respect to the "damnable" character of the alternate current, to cork up their ink-bottles and retire from the field. There is a fertility of resource, a picturesqueness of statement, a wealth of argument, and a mastery of statistics, exhibited in the work of the railway man, which even an university education and a long residence west of the Missouri river, seems utterly inadequate to account for. Seriously, every one interested in electrical industries should use his efforts to put an end to this state of affairs, alike useless, discreditable and harmful to all electrical interests. Whether justifiable or not in its original application it is certainly true in this connection, that the "injury of one is the concern of all."

TRYING IT ON THE DOG.

A PROMINENT electrician of this vicinage, who has not yet reached that stage of development which permits him to see a legitimate field of usefulness for any species of electricity the E. M. F. of which exceeds 110 volts, was recently appealed to by a reportorial representative of one of our esteemed daily contemporaries for information respecting the *modus operandi* of capital punishment by electricity. With his customary urbanity the electrician at once volunteered, in the true scientific spirit, to try it on a dog,—a yellow dog. We can almost see the childlike and bland smile of the experimentalist as he proceeded to prepare an electric current—an *alternating* current, as the reporter was carefully instructed to inform the public—of between 1,000 and 2,000 volts potential, which was duly administered to the unfortunate cur, with results too shocking to admit of being narrated here. This leads us to remark that if it were only possible—and perhaps it is possible—to educate public opinion up to the point of demanding legislation which should render compulsory the use of direct currents for lighting and other industrial purposes, and of alternating currents for extirpating criminals and other creatures whose room is considered preferable to their company, there would be little further occasion for the services of a certain electrical "literary bureau" whose efforts in the dissemination of useless misinformation have been prosecuted with a zeal and industry worthy of a better cause.

ANOTHER RICHMOND IN THE FIELD.

"I AM in the arena to fight these claims to the end, and warn all parties against entering into contracts with companies or persons offering the long-distance system of incandescent lighting by the alternating converter system for sale."

Thus energetically, not to say truculently, ends a letter dated April 28, 1888, which we received from Walter K. Freeman, electrical engineer, soon after its date. It was apparently a circular letter, and in it Mr. Freeman claimed "solely and absolutely" to be the inventor of the "alternating or converter system of electric lighting." The letter was designated "No. 1," and the author promised that No. 2 would "explain Mr. Red Book's position relative to the incandescent electric lamp." We have awaited No. 2 with interested expectancy, but, so far, in vain. Mr. Freeman is reported to have allied himself recently with the Fort Wayne Jenney Electric Light Co. We trust that engagement will not prevent his completing the series of letters fairly promised in his initial communication.

THE systematic and complete removal of dead wires from the streets of New York is the most obvious and needed step towards reducing present risks to life and property, and for improving the electric service of the city. No one knows how great a mileage of unused conductors a thorough examination of the lines of the telegraph, telephone and electric light companies, together with those of the police and fire alarm systems, would reveal; but it would scarcely prove less than some "thousands of miles," to use the words of Mr. W. L. Strong, president of the Brush Electric Illuminating Co. as reported in an interview recently published by the *New York Herald*. Here is a present danger and constant menace—concerning which there can be no difference of opinion among electrical engineers—easily and immediately removable. We have a board of electrical control. Must the dead wires remain until we have had a few more "accidents?" Apparently not, we think, since the appointment of Mr. Schuyler S. Wheeler, June 15, as electrical engineer to the Board, gives assurance that, so far as he is concerned, immediately practical measures for the improvement of the electric systems of the city will have prompt and intelligent consideration and action. We understand that Mr. Wheeler has already initiated a campaign against the dead wires.

VERY significant of the estimate placed upon the conduits provided by the politico-histrionico-legal subway commission of this city, now called the Board of Electrical Control, is the following paragraph from Mr. Strong's remarks reported in the *Herald* interview mentioned before.

> To show you that our company are ready and willing to comply with the law, I mention that we were about to sign a contract on November 1 last for a nine wire cable, which we intended to lay in the conduit along Broadway, from Fourteenth street to Thirty-fifth street. The makers were to guarantee the wire for five years, and were to give a bond to that effect. They asked time to examine the conduit, and when they had done so they came to us—five days later—and withdrew their guarantee. I am not at liberty to tell you why they withdrew it, but you can draw your own deductions. After this refusal we made an investigation on our own account and found that even if we had laid the wires we could not have made house connections without extra expenses that would soon have bankrupted us.

TUESDAY evening, June 19, Mr. F. J. Sprague read a paper on the "Solution of the Street Railway Problem," before the Institute of Electrical Engineers, at the Library building, Columbia college. We regret that it has not been found practicable to supply copies of the paper in shape for printing to the electrical journals in time for its appearance in this issue of THE ELECTRICAL ENGINEER.

After some general discussion of the difficulties to be encountered and surmounted in street-car traction, Mr. Sprague described the electric motor system now in use on the lines of the Union Passenger Railway Co., Richmond, Va.; in the construction and operation of which many very serious problems had been met with. It would hardly be proper to make extended comment in advance of the publication of Mr. Sprague's paper. It is sufficient to say that his account of the successful accomplishment of difficult tasks on the Richmond lines, particularly the climbing of steeper grades than have been thought practicable for self-propelled cars, implies a most promising outlook for a continued and accelerated growth of electric railroading in city streets. Mr. Sprague illustrated his descriptions with a large number of admirable photographs, projected on the lecture room screen by the new lantern presented to the Institute by its president, Mr. Edward Weston.

THE "alderman business" is proving quite as serious an obstacle to electric street railway enterprise in this city as the competing horse and cable systems. The scientific objection of the aldermen to storage battery cars, to wit: the danger apprehended from "accumulations" of electricity, still stands in the way of a permit to use on Fourth avenue the cars contracted for with the Julien Electric Co. Notwithstanding the considerable delay that will doubtless attend the process of illuminating the aldermanic mind on the electrical questions involved, we are glad to know that the promoters of the project are confining their efforts to that point, and evince no disposition to "talk business" with aldermen or their representatives.

THE North and East River Railroad Co.'s troubles are of much longer standing, and are due to obstruction by the Bleecker Street company, the present owners of which decline to carry out a verbal agreement to give the North and East River company, the use of about 1,000 feet of their track in Fulton street, which the late Jacob Sharp is said to have made soon after the formation of the latter company. The North and East River company, as our readers will remember, own a charter (under the Cantor Act) to run an electric railroad through Fulton street from river to river connecting Brooklyn and Jersey City ferries. The Bentley-Knight conduit system was adopted and the company began construction, purchased equipment, and would probably have been prepared to run its cars last October but for the failure of the Bleecker Street company to come to terms. Legislative relief was sought but was defeated in the Senate, and the dead-lock continues. As under the Cantor Act, the North and East River company must pay to the city over one-third its gross receipts, while the Bleecker Street company pays nothing, and as the public need of a cross-town line in Fulton street is obvious to all, it will be seen that the Bleecker street company is not only blocking the operation of an electric railway, but standing in opposition to manifest public interests.

IN the suit of the American Bell Telephone Co. against the Cushman Telephone Co., the evidence having been taken during an extended period, argument was begun before Judge Blodgett, at Chicago, June 4th, and concluded June 9th. The complainant's argument was made by Mr. Geo. L. Roberts and Mr. B. F. Thurston, and that of the defendant by Mr. C. D. F. Smith and Mr. J. L. High. The case has attracted much attention and interest, particularly in the west, where Cushman claims to have made his "talking boxes" some thirty odd years ago. He far outstrips Drawbaugh in his allegations of priority, claiming to have discovered the principles of the telephone in 1851 at Racine, Wis. Unless Cushman's narrative and testimony prove better able to bear legal and judicial analysis than did those of the more modest Pennsylvania anticipator, we may shortly expect another important judgment sustaining the Bell patents.

IN view of the large extent of arc lighting in this city—Mayor Hewitt's recent investigation showing that there are some seven thousand arc lights in use, while there have been but four fatal casualties since their introduction ten years ago—it is quite true that the industry is carried on with less danger to life than many others not usually deemed especially hazardous; but comparative immunity ought not to be pleaded in abatement of the demand for every safeguard known and possible of application.

THE New York *World*, in its issue of June 11, gave the names of 21 citizens who had been run down and killed by reckless drivers in the streets of New York since January 1, 1888, not to mention 130 more who have been more or less seriously injured from the same cause. During the same period of time two citizens have been killed by electric wires in the streets.

.... IN any system of electrical distribution, the greatest economy is attained when the cost of the energy lost in heating the wires equals the interest on the cost of the copper.—*Sir William Thomson.*

OBSERVATIONS.

AWAY back in the fifties the observer remembers of hearing his grandfather speak of a friend who was killed by a "thunder-bolt."

This term we don't often see now, nor indeed is it much used except by poets, who have a license and use it, and by the penny-a-liners of pink evening newspapers.

When thunderbolts are mentioned, one is reminded of the old notion that existed before Wall speculated upon, before Gray asserted, and before Franklin demonstrated the identity of electricity and lightning; the old notion that something solid and intensely hot, passed along the track of a lightning flash, and buried itself in the ground. Perhaps this notion arose from the concurrent influence of two classes of phenomena. When lightning strikes the ground it often bores a hole of considerable depth, which is found to be lined with a slag of vitrified sand. This presents no difficulty. But *aerolites* are sometimes found in the holes which they have made, still intensely hot, as a result of their rapid passage through the, to them, unusual density of our earthly atmosphere. A hasty generalization seems to have connected these two absolutely unrelated phenomena, and the supposititious thunderbolt is thus accounted for. The proverb about a lightning flash from a clear sky may also be accounted for by the occasional visit of these strangers from a strange land.

These observations were all suggested by a stray expression come upon the other day in Carl Hering's new book, which by the way, considered as a whole cannot be overpraised. On page 12, if memory is correct, we find the expression "bolt of lightning." It is doubtless intended merely as an equivalent phrase for "a stroke" or "flash of lightning," and may be equally proper; but a little thing will sometimes start a train of reflection, and it was Mr. Hering's "bolt of lightning," that caused the above bolt of thunder.

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THE subject of thunder and lightning "bolts" affords an excellent opportunity to slide off into a second observation, which is that Mr. Delany's paper on the "Protection of the Human Body from Dangerous Currents," read before the Institute of Electrical Engineers, May 16th, was most timely and valuable. The truth brought out in the discussion, that both electromotive force and quantity are required to shock fatally a human being, is worth everybody's while to know; as is also the fact, which curiously enough few persons, even of large experience seem to appreciate, that lightning possesses in addition to its enormous electromotive force, considerable volume. It is true that Faraday and H. W. Spang are at swords' points here; but Spang is, upon this issue, in the right of it. It is to be hoped that Mr. Delany's plan of shunting will be successful.

The observer owns to a faint preference in favor of first "trying it on a dog" or perhaps some animal of a larger size, and also to a hope that Mr. Delany will not try it himself with a dangerous current, without first adopting some similar precaution; for while it is certain that Ajax Delany defying the lightnings, would be an impressive and instructive spectacle, and one well worthy of the pen of a Homer or the pencil of a Paul Veronese, he is altogether too valuable a man to lightly risk his life, e'en though it be in the cause of science.

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CLOSELY allied to the electro-medical spectacles, which the observer commented upon last month, is a "*Headache Curing Hat*" which forms the subject-matter of a later patent, No. 383,899.

An ordinary "Derby" has two flat cases, one made of copper, the other of zinc placed inside its lining; one case is secured in the front of the hat, the other in the back. The cases are perforated, and hold absorbent material like woolen cloth which is saturated with dilute acid. The two cases are united by an insulated wire which runs round the interior of the crown of the hat. The perspiration is stated by the patent to be absorbed by the woolen material and to aid in generating the electricity. The wearing of this hat is warranted to relieve headaches. Very likely it will by the aid of "Christian Science," but will it not be equally competent to produce a headache if worn by a person who has not one ready made? As to the perspiration, it is quite conceivable that anyone wearing such a hat will indeed perspire freely.

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AND while on the subject of patents, it may not be out of order to record that an electrical invention of universal interest was patented on May 29th, 1888 (see U. S. patent No. 328,485), to one A. C. Palmer. We have had neither time or opportunity to accord this invention the study it obviously deserves; but there can be no doubt that the "Electric Punch Register" (this being the modest but descriptive title of the invention) will meet a long felt want. "Punch, Brothers Punch with Care." Since writing the above we have been harassed by the feeling that, possibly the Punch we have been thinking of, may not be the Punch which is to be registered.

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THE application of the telephone as a substitute for the galvanometer in electrical measurements with the Wheatstone bridge has often been alluded to in technical journals, and seems to have lately furnished a subject for some discussion in the electrical newspapers of England and the United States.

It may be of interest to note that apparently the first published suggestion of such a use is to be found in a communication by Herbert Tomlinson to *Nature*, March 14th, 1878.

• • •

THE "Spirit of '88" prevails even in political convention despatches. We are assured by Associated Press despatches, that "*Chicago is like a battery or a dynamo, sending out a magnetic current in every direction.*" It appears that Chicago is preserved from the alleged infringement of Mr. Edison's blanket mortgage on the distribution of electrical energy only by the fortuitous but lucky circumstance that the currents it evolves are not electric but magnetic.

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UNDER the legend, "Bury your Watch," the Boston *Herald* of June 6th, reproduces an item of news written from Connecticut to the New York *Sun* by one of its correspondents. It appears that a homœopathic physician of Ansonia discovered to his sorrow —what others before him had found out—that evil communications, of a magnetic nature, corrupt good watches.

His remedy was novel. Inclosing the wayward watch in a cloth bag, he buried it in a box of earth. It remained there three days, and in 27 hours from the time of its disinterment it had turned neither to the right hand nor to the left, except in the accomplishment of its ordinary and legitimate work; to adopt the exact language of the correspondent: "It has not varied a hair."

The reporter naturally remarks on the simplicity of the remedy, and reviles the jewelers who have foolishly been using demagnetizers and anti-magnetic appliances vouched for by the eminent of the electrical profession. Our *Alma Mater* is surely verifying the words of the many writers who pronounce her "a great magnet," and her children are to be congratulated that even a small portion of her —in a box—is able to counteract with *its* magnetism, that of the machines that send forth their light by night and their power by day.

POINTERS.

.... IN reality, all machines are alternate current machines, the currents appearing continuous only in the external circuit during their transit from generator to motor.—*Nikola Tesla.*

... NOTHING can now permanently check the growth of the telephone, the telegraph or the electric light. They have become necessities of our civilization, and any hasty or ill-advised enforcement of the law to convert all aerial to underground systems which should result in serious injury to them, would prove the surest way to perpetuate the nuisances of overhead wires and poles in the streets.—*Professor G. W. Plympton.*

.... I CANNOT regard a lightning flash as an example of a small current. The heating effects which are present in such cases are sufficient to show that the current may rise to very many hundreds of amperes.—*Elihu Thomson.*

.... AFTER 25 years of the most careful study of the street railway problem, I am convinced that the motor of the future is steam.—*Louis Ransom.*

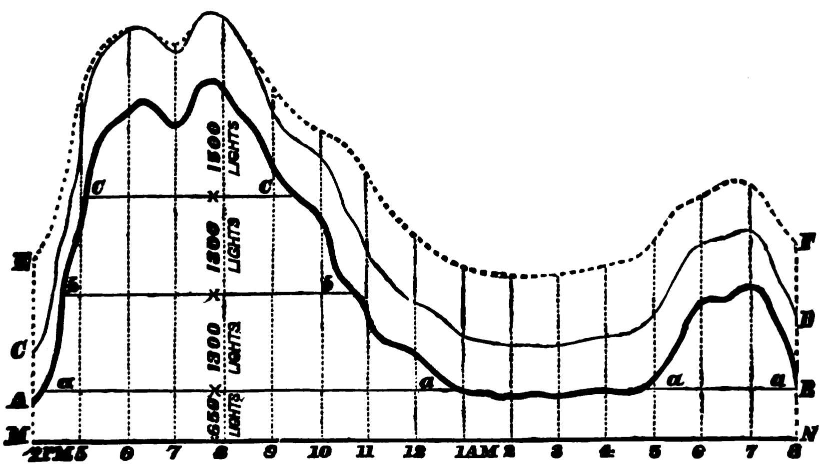
ARTICLES.

HIGH AND SLOW SPEED ENGINES.

BY J. A. POWERS, C. E.

The able paper read at the late convention of the National Electric Light Association, at Pittsburgh, by Mr. Wm. Lee Church (see Electrical Engineer for March, 1888, p. 97), suggests some points in the relative coal economy of high and slow speed engines which it is believed are not fully nor fairly treated in that paper. That the experience of Mr. Church in the making, testing and using of high speed engines, leads him to the conclusion that the independent high speed engine is the best in average coal economy in incandescent light stations, because the stations which he cites as users of large engines are less economical of coal than other well designed stations using high speed engines is no proof that high speed is a better economist than slow speed, even for the variable loads of incandescent light stations. The great variety of boilers, settings and draft appliances, and in the quality of fuel in use render any comparisons of coal consumption valueless except as a general index of possible results. The only fair way to state the general problem is to make a distribution of the steam consumption, which would be about as follows:

First.—Steam loss by radiation, and used for boiler feed and in providing water supply, etc. This will constitute a certain nearly uniform amount per day for any given plant when under steam.



Mr. Church's Figure 2.

Second.—Steam consumed in engines, as shown by indicator cards.

It is this second item with which we are concerned, as the first will be an individual factor for each station.

We should then consider the nature of the loads imposed on the power plant in every electric light station, and then deal fairly with the problem. These loads are—

1st. Friction.—*a*, consists of friction of engines in use; *b*, friction of shafting in use; *c*, friction of dynamos and belting in use.

2d. Effective load; power required for conversion from mechanical to electrical energy, including the losses in conversion out-put.

It will be evident that the "friction" load in the case of independent engines will be a nearly uniform percentage of the electrical out-put at any time, providing each engine is loaded to about its fair capacity, while in the case of slow speed engines there will be a certain constant quantity introduced, viz., the friction of the engine shafting and dynamos necessary to be run whether without load or not when certain dynamos are in operation. This is a consequence of the inflexibility of the shafting system, and we must, therefore, under light loads pay a penalty of a larger percentage of friction to load, than with independent engines, and this will entail an extra coal expense. The question of the coal economy of the two systems, therefore, depends on whether the slow speed can save enough coal when under heavy load to more than counterbalance the losses by friction under light load.

It is not to be presumed that any sane man will design a station for such a loading as Mr. Church shows in his diagram No. 2, which is reproduced below, to be run by a single engine large enough to handle the entire load. No steam engineer would consider the idea of handling the lightest loads—say from 60 to 75 h. p.—with an engine of 400 horse capacity. The necessities of any but the smallest station call for a divided engine plant. If the question of reserve power be left out, a station of 400 horse might be properly provided with one engine of 100 horse and one of perhaps 300 horse, both slow speed if desired. If the smaller engine be a high speed the station will be on the same terms as a station with exclusively high speed engines during the hours of light loading, which would limit the question of relative coal economy to the hours of heavy loading, say from 4 till 11 P. M., and 5 to 8 A. M. The arrangement for such a plant should be to drive each engine to a section of shafting conveniently arranged to give each engine its separate shaft and dynamos. These sections may be coupled by a friction clutch when desired, and friction clutch pulleys should be used for the driven pulleys from the engines. The dynamos may be provided with loose pulleys on the shaft or with some kind of belt holder to enable the dynamo to be stopped without interfering with the line shaft. The dynamos may be belted in opposite directions in pairs when space will permit, so as to reduce friction to a minimum.

Now in comparing the relative friction of the two systems the friction of dynamos may be neglected, since any dynamo may be stopped as soon as its load is taken off, in either system; in one case by stopping an engine, in the other by shifting a belt. This brings the question of friction down to whether the friction of large engines and shafting exceeds that of small engines alone.

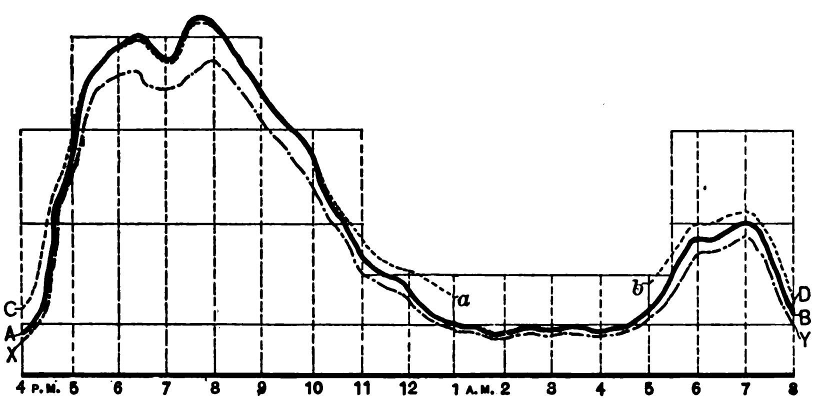
The friction of high speed engines is variously stated by engine builders at from five to eight or 10 per cent of full load. Probably the latter figure is not far from the truth, and if it were too large a percentage for full loading it must be remembered that a minute subdivision of power would be required to bring this about, and that this is neither practical in cost of investment nor of operation, and that a reasonably divided power plant will not ensure high speed engines always working on full loads. The percentage of friction will be greater under less than full loading, since engine friction seems to be nearly constant for all loading, in well designed engines.

Mr. Church states that shafting and engine friction ranges from 12 to 20 per cent. upward and not infrequently rises to 30 per cent. This may be possible, but it certainly is not so in all cases, and if we allow the same skill in designing a slow speed station which some of Mr. Church's show, it is entirely unnecessary. Indicator diagrams from a 20 x 48 Corliss engine driving 16 feet of $3\frac{7}{8}$ shafting at 320 revolutions, one 50-light Thomson-Houston 1,200 c. p. and one United States 20 arc light dynamo, out of circuit showed a total of $14\frac{6}{10}$ h. p., and deducting 3 h. p. for the dynamos, leaves $11\frac{6}{10}$ h. p. for friction of engine and line shaft, or $5\frac{8}{10}$ per cent. if the engine be rated at 200 h. p. This would indicate the engine friction to be as low as three per cent. The same engine driving 17 feet of $4\frac{7}{8}$, and 33 feet of $3\frac{7}{8}$ shafting with pulleys but

without belts, showed 22½ h. p. or nine per cent. for engine and shafting. If the dynamos are belted in pairs with belts pulling against each other, there will be no increase of their friction under load. A slight increase under load may be expected from the extra strain of the main engine belts under load, but a fair outside limit of 10 per cent. for engine and shafting friction may be taken from these data.

Now in the diagram shown of the load of an incandescent station (reproduced above) Mr. Church says that the heavy lines, A B, represent the fluctuation of the *actual load*, such as would be determined by indicating a series of independent engines, and the area enclosed between it and the base line, *mn*, may be denominated the net power required. This presumably includes the engine, belting, and dynamo friction of the high speed engine. Then Mr. Church proceeds to saddle all the sins of the high speed system on the slow speed system by saying: "The fine irregular line, *cd*, encloses the gross load when driven by a single large engine, being equaivalent to the *net load* plus the friction of the shafting and pulleys required in transmission." Thus assuming that the net load is the *indicated horse power* of the high speed engines, entirely ignoring the frictions which are chargeable to that system.

Now let us take some liberties with Mr. Church's diagram (see the figure below). We have reproduced his heavy line A B of gross loading as shown by the indicator on the high speed engine plant. From this line is constructed a new curve, shown in broken and dotted line, which is obtained by deducting from the ordinates to the curve A B, the 10 per cent of friction chargeable to the high speed system. This new line, X Y, is the true line of net power, and it is from this line that we must construct our friction curve for the slow speed system. This curve, C D will be found by laying off a line above the curve X Y, and distant from it 10 per cent of the maximum power in use. The diagram now shows simply the power used in driving the entire station, and does not consider the coal economy of the engines, which in Mr. Church's diagram is charged up against the slow speed system in the curve E F, and is not considered in the high speed curves at all. It will be noticed that this slow speed power curve, C D, nearly coincides with the gross power curve A B of the high speed system during the times of heavy loads, and that it rises above it as the load becomes less. The station is supposed to be operated by starting the 300 h. p. engine at 4 P. M. and supplementing it with the 100 h. p. at 5 P. M., then dropping off the 100 h. p. at 9 P. M. and starting it again at 11 P. M., shutting down the large engine at the same time. At 5.30 A. M. the 300 h. p. would be started and run till 8 P. M.; the 100 h. p. going out of service at 5.30 A. M.



We have now to consider the steam economy of the various types of engines in order that we may discuss intelligently the relative economy of the two systems. The following is a summary of the statement of engine builders on the point:

	Lbs. steam per h. p. hour.
High speed engines of 50 to 100 h. p.	28 to 32 lbs.
Corliss engines of 200 to 400 h. p.	
Single cylinder, high pressure	24 to 26 lbs.
" " condensing	20 to 21 lbs.
Compound, condensing	15 to 16 lbs.

These results would give with an evaporation of eight pounds of water per pound of coal,

	Coal per h. p. hour.
High speed	3.50 to 4.00 lbs.
Corliss single cylinder, high pressure	3.00 to 3.25 lbs.
" " " Condensing	2.50 to 2.62 lbs.
" Compound Condensing	1.87 to 2.00 lbs.

These results do not vary much from good practice for the Corliss engines, but the departure is very wide from the ordinary results in the case of the high speed type. A central station operator of great experience informed the writer not long since that he allowed six pounds of coal per arc lamp per hour as an average result. This would not be less than six to seven pounds of coal per horse-power hour for engines of 50 h. p. The experience of the writer goes to prove that this result is about correct for engines of that size. For 100 h. p. engines a result perhaps one pound better can be had. The results recently shown in changing some stations from high to slow speed seem to indicate the correctness of these results, one such case reporting a saving of 50 per cent. in fuel. Another case where a 20 x 48 Corliss was substituted for three 50 h. p. high speed the results were fully as good, though the Corliss engine was a part of the time under a very light load. The most curious result is that this engine is sometimes run under a load of 125 h. p. during a dark day in place of the 50 h. p. engine which ordinarily carries a day load of 60 h. p. and actually carries the heavier load with the same coal though the Corliss engine works at only half load, while the 50 h. p. was but slightly overloaded, and at a comparatively economical point of cut-off. This is a comparison of much value in considering the relative merits of the two systems, since the indications are that the Corliss engine is more economical even when under half loading than the 50 h. p. high speed engine is at a fair load.

Now let us consider the comparative coal consumption of the two systems on the power curves we have laid out in diagram No. 2. The planimeter shows between the base line and the power lines,

A B	h. p. hours 3,300	
C D		
4 to 11 P. M.		
11 P. M. to 5 A. M.		
5 A. M. to 8 A. M.		3,580

If these quantities are multiplied by the proper coal rates we have:

High speed A B, 3,300 × 5 lbs.		= 16.500
Slow speed C D.		
High pressure	3,300 × 3.25	— 10,750
Condensing	3,300 × 2.62	= 8,646
Compound condensing	3,300 × 2.00	= 6,600

These results show savings as follows:

	Saving.
High pressure Corliss	5,750 lbs.
Condensing "	7,854 "
Compound condensing	9,900 "

over the high speed engines at 5 lbs. coal per horse-power per hour.

Now the Corliss engine will not, of course, be working on an economical loading during part of the time, but in order to get an extreme comparison let us suppose that the Corliss system is run at full power whenever in use at all, or in other words, that the coal consumption is the same whether the engine is partly or fully loaded. I do not be-

lieve that the most ardent advocate of the high speed system will claim that a Corliss engine will burn *more* coal under light load than when fully loaded.

The schedule as above indicated would give the following horse-power hours:

310 h. p.,	4 to 11 P. M.	2,170
	5.30 to 8 A. M.	775
125 h. p.,	5 P. M. to 9 P. M.	500
	11 P. M. to 5.30 A. M.	812
		4,257

which would give the coal consumption—

High speed at 5 lbs coal per h. p. hour		— 16,500
Corliss, high pressure	4,257 × 3.25	— 14,835
" condensing	4,257 × 2.62	— 11,153
" comp. condensing	4,257 × 2.00	— 8,514

So that the high pressure Corliss engine is the better on coal consumption even under the *reductio ad absurdum*, that there is no saving in coal as the load becomes less, and giving the high speed engine the benefit of a coal rating at full load. It will be noticed also that the coal rates taken for Corliss engine, as above are the largest rates shown by ordinary practice and make no allowance for expert care which has its effect on all engines in saving of leakage and friction.

This discussion leads us to about the following conclusions as to the coal economy of the various types of engines, taking the high speed engine as unit:

	Coal consumption, lbs.	Percentage, saving.
High speed	16,000	0.00
Corliss, high pressure	11,000	.31$\frac{3}{10}$
" condensing	9,000	.43$\frac{3}{10}$
" comp. condensing	7,000	.57$\frac{3}{10}$

This is believed to be as fair a statement as can be shown from the average practice. These results speak for themselves. We must use condensing engines wherever possible, and to do this we must locate near a plentiful supply of water. If no stream or pond is convenient we must try driven or artesian wells. Both have proved effective, and location must determine the choice. The saving by condensing is not less than 25 per cent. under full loads, and one-quarter of our coal bill will pay large interest on any reasonable expenditure to obtain water supply.

First cost of steam plant is a matter of importance in station construction, and may be fairly stated about as follows for the different types of engine.

One 100 h. p. engine high speed	\$1,500 to \$1,800
" 200 " Corliss "	4,500 " 5,000
" " " " condensing	5,200 " 5,800
" 350 " " comp. condensing	13,000 " 14,000

If we add shafting to the cost of the last three engines we shall have a cost per horse-power—

	Cost per horse-power.
100 h. p. high speed engine	\$15 to \$18
200 " Corliss high pressure	30 " 32
200 " " condensing	33 " 36
350 " " comp. condensing	45 " 48

This is as far as the high speed advocate usually goes, but it is not far enough. If we need less steam we require less boiler capacity, and this reduction will be nearly in proportion to the coal rates of the different types of engines. A well set boiler of 60 inches diameter by 17 feet long with good draft will supply steam for three 50 h. p. engines, but will need forcing to do it. The same boiler will supply a 20 × 48 Corliss condensing engine of 250 h. p. much more easily.

We may fairly state the cost of steel boilers well set, as required by the different systems, about as follows:

100 h. p. high speed	\$16 to \$18 per h. p.
200 " Corliss	12 " 14 " "
200 " " condensing	10 " 12 " "
350 " " comp. condensing	7 " 9 " "

So that the total cost of steam plant will be about as follows:

High speed	\$31 to \$36 per h. p.
Corliss	42 " 46 " "
" condensing	43 " 48 " "
" comp. condensing	52 " 57 " "

Now let us compare our results of first cost and saving together,

	Cost per cent.	Coal consumption, per cent.
High speed	\$1.00	100
Corliss	1.31	62
" condensing	1.36	56
" comp. condensing	1.62	44

and with coal at \$3 per ton on the above schedule and interest at 6 per cent. the results will be for the 400 h. p. station under consideration—

	Cost of coal per day.	Saving in coal over high speed.	Interest per day on 400 h. p.	Loss in interest.
High speed	\$24.75	0.00	2.36	..
Corliss h. p	18.90	5.85	3.08	.72
" condensing	15.24	9.51	3.15	.79
" comp. condensing	11.64	13.11	3.75	1.39

Or in a 400 h. p. station the high pressure Corliss engine beats the high speed system \$5.13 per day, Corliss condensing \$8.72, Corliss compound condensing \$11.72.

It may be said that these figures are theoretical to some extent, but they will be found to agree pretty closely with the results of good practice for both systems.

It is to be noted that a number of stations lately laid out contemplate the use of Corliss engines, in part at least; and some of them from the plans of the best engineers we have.

The writer hopes to supplement this paper with a statement of some accurate tests on engines of each type, at an early date.

A STUDY OF CERTAIN ERRORS IN THE CONSTANT SHUNT METHOD.[1]

BY WILLIAM L. PUFFER, S. B.

A VERY neat and valuable application of Ohm's law is that usually called the shunt method for the determination of current. The method is described in the Munich, Vienna, and Philadelphia reports on dynamo tests as well as in the ELECTRICIAN AND ELECTRICAL ENGINEER, for January, 1885.

The principle is this: if a conductor of constant unknown resistance be placed in a circuit, and currents of different strength passed through it, there will be a difference of potential at the terminals of the conductor proportional to the currents flowing; and if this conductor be placed as a shunt upon a reflecting galvanometer whose resistance is high as compared to the conductor, and whose deflections are proportional to currents producing them, then the deflections will be proportional; first, to the currents in the galvanometer circuit; second, to the potential difference in the conductor; and third, to the currents in the conductor.

In order to extend the range of the apparatus, the galvanometer deflection can be kept the same by changing the total resistance in its circuit; then this total resistance is also proportional to the potential difference in the conductor. In order to save time, the galvanometer deflection may be nearly the same, and the product of the deflection and corresponding total resistance taken; these products will then be a measure of the corresponding currents in the conductor. If a known current be passed through this conductor or shunt, and the galvanometer deflection and total resistance of the galvanometer circuit multiplied, and the product divided by the known current expressed in am-

1. Read at a meeting of the American Academy of Arts and Sciences, January 11, 1888.

peres, we get the constant of the apparatus for amperes. To find value in amperes of an unknown current, we have only to note the deflection and total resistance in galvanometer circuit, multiply them, and divide by the constant. Or we could divide the known current by the product of resistance and deflection, and get a constant by which to multiply the resistance and deflection obtained with the unknown currents.

The range of the method is very great, and is, perhaps, limited only by the difficulty of making a suitable shunt of such a cross-section as to be free from injurious heating by the currents used.

Wishing to employ this method in the Rogers Laboratory of Physics in a slightly different way, requiring that the shunt resistance be known, I made some experiments to determine the resistance of a german-silver rod three feet long and 0.6 inch in diameter, with the intention of using it as a constant shunt of *known* resistance for currents from about 1 to 60 amperes. An inch from each end a small wire of german silver was silver soldered in a hole drilled nearly through the rod, and the lead wires running to a low resistance galvanometer were connected by screw-clamps. On the ends of the shunt were soldered brass screw connection for insertion of the main wires.

A standard ohm was placed in circuit with the shunt by means of mercury cups, and the resistance of the shunt found by comparison of the potential at its terminals with that at the terminals of the ohm, using a Hartmann dead-beat galvanometer and resistance box as usual with the shunt method.

The results were very unsatisfactory, although care had been taken to prevent, as far as possible, any error due to change in temperature, by placing both the shunt and the standard ohm in a water bath, and noting the temperature both before and after a set of readings.

As the observations were taken in a short time, and the resistances measured immediately afterward, it is not probable that there could have been any noticeable change during the experiment.

With the shunt in water, the results checked within about 0.3 per cent., the highest being 0.00 085 39, and the lowest 0.00 085 10 ohm. When the shunt was in melting ice the results were more variable, and in air very bad. A careful test of the wires and connection showed that when there was no battery in circuit, there was a variable electromotive force in both the galvanometer circuit, and in the shunt itself, sufficiently great to account for the errors in previous work.

The error in the galvanometer circuit was avoided by greater care in manipulation and the use of a mercury commutator; but the shunt proved so troublesome that a study of the nature of the small, disturbing electromotive force observed seemed desirable.

As this error, which I attributed to thermal action, was entirely negligible in the standard ohm because of the comparatively high difference of potential produced by the calibrating current, I thought that a german-silver shunt, capable of carrying 5 to 10 amperes, having a resistance of from 0.1 to 0.2 ohm, might be compared with the ohm, and then with the shunt, without any appreciable error from heating or thermal action.

The following is a brief description of the shunts made, and the arrangements for taking observations and avoiding errors :—

The large german-silver shunt has already been described. The standard german-silver shunt was made of a 50 foot length of wire of one-quarter inch diameter, drawn to order and of the quality known as "18 per cent." A short length of No. 14 german-silver wire was looped around this shunt near each end and silver-soldered to it, using borax as a flux, and similarly a set of copper wires as well, thus giving me virtually two shunts of the same resistance and material, differing only in the metal wires used for the potential leads. The shunt wire was doubled and bent back and forth through porcelain insulators fastened to a piece of board. Also a copper shunt was made of two pieces of No. 00 wire, each 11 feet long; these were connected by being soft-soldered into a brass block, using resin as a flux, and then coiled in the same directions, to avoid magnetic disturbance, and suspended from ebonite supports in a stone jar. At three places on this shunt—near each end and in the middle near the brass block—were soldered a set of four wires. Each set of four contained a german silver and a copper wire, silver-soldered with borax, and a similar pair soft-soldered with resin. This was equivalent to 12 simple copper shunts, with different leading wires and solders.

Each of these three shunts was placed in a tank of water provided with a thermometer. The potential wires were carried to mercury cups and commutators on a table 30 feet away, where the resistance boxes were placed.

The galvanometer was a double coil Hartmann, with bell magnet and copper damping-block; the deflections were read by a telescope and scale at a distance of 3.68 metres.

The galvanometer wires were soldered to amalgamated brass rods held in a piece of ebonite provided with a long handle, used in changing the connection from one set of wires to another.

In order to avoid temperature correction, the shunts were placed in water and carefully watched until it was evident there was no perceptible heating of the water or wires by the current. A loop of the galvanometer leads was always connected to a Wheatstone bridge used to measure the resistance in circuit. There was never any change large enough to cause any trouble, as the measurements were all taken in a short time, and the rise of temperature was very slow.

The deflections were always brought to about 10 double centimeters each side of the middle of the scale, and were written 1,000, calling the tenth of smallest division unity. Within the limits of the scale the proportionality of the deflections was nearly perfect, and quite so within the limits of working. The error due to change in length of the suspending fibre was studied, and found to be negligible only when the precaution was taken to compare a mark on the mirror with a mark on the metal frame of the instrument, and adjust the height of the mirror to 0.1 or 0.2 millimeter. The torsion of the fibre was negligible in the range of deflections used.

The galvanometer and its connecting wires had a resistance of 4.7 ohms, and was used as a voltmeter for measuring the thermal electromotive forces with an accuracy of about five per cent. The factor 0.00 000 040 was used to multiply the deflections by in order to obtain the thermal action in volts, when no resistance other than the galvanometer and connecting wires was in circuit.

It was assumed that these shunts would be calibrated with a current of one ampere, and that an accuracy of one part in 1,000 was desirable. The table gives the resistance of the shunts, and also the volts corresponding to an error of 0.1 per cent. of the difference of potential caused by a calibrating current of one ampere. These small electromotive forces are represented by two units of deflection of the voltmeter in the case of the copper and the large german-silver shunts, and 2,000 with the standard shunt.

	Resistance in ohms.	0.1% P. D., due to an ampere.
Large german-silver shunt..........	0.00 085	0.00 000 085
Standard german-silver shunt.......	0.16	0.00 016
Half of copper shunt	0.00 070	0.00 000 070

The large german-silver shunt in air often showed from one to three units deflection, sometimes in one direction and sometimes in the other; but when placed in water this error was reduced to a much smaller amount and seldom could be detected. At one time there seemed to be a vari-

able deflection, which was traced to the contacts in the screw connection used to join the galvanometer leads to the shunt wires; this was easily removed by bending the wires until the clamps were under water. After this I could never detect any deflection caused by thermal action in this shunt, although owing to the low resistance of the shunt an error of 0.05 per cent. would cause so small a deflection that it might pass unnoticed.

The copper shunt, with its different terminals, proved very interesting, and exhibited a great variety of thermal action which would, in many cases, be too large to be neglected if the shunt was to be used for comparison of currents.

The largest deflections were always found with the german-silver wires, and the least with copper wires with soft-soldered connection. The deflections were seldom twice alike even with the same wires, ranging from 0.0 to 20., being positive at one time and negative at others. The difference between the silver solder and the soft solder was not particularly marked, but seemed to be in favor of the soft solder, both with the copper and german-silver leads. These deflections were always smaller and more regular when the shunt was in water than in air. It often happened that the copper soft-soldered leads gave no indication of thermal action, and I never saw any indication of trouble from the double-soldered connection in the middle of the shunt.

This shunt was made to correspond approximately to some of the shunts described in articles on the shunt method of determining currents both in regard to size and length of wire and method of connecting the lead wires.

The thermal action in the standard german-silver shunt was very much greater than in any part or combination of the other shunts, being larger when the copper leads were used by about seven per cent.; still, even these large thermal E. M. F's were quite small when compared to that produced by the calibrating current, and could have been safely neglected if an accuracy of 0.1 per cent. was required. I thought I could now compare this shunt with the standard ohm easily enough; and then with the other shunts by using a current of several amperes, to get so great a difference of potential that the thermal effects would be drowned. I changed the storage battery letting the current pass through all three shunts, and after a few hours I broke the circuit, and tested the shunts to see whether the current had perceptibly heated them, although a sensitive thermometer showed no change. The copper and large german-silver shunts seemed about as usual, but the standard gave me a deflection of 2,000, which rapidly diminished. This was far too small to be of any effect with this particular shunt, but it was very suggestive. Examination of the shunt showed a slight blackening at the positive end and a few bubbles of gas, probably due to slight decomposition of water, as the difference of potential had been about 1.8 volts. A reversal of the current caused the blackening to appear at the other end of the shunt, and a slight lessening of the discoloration produced by the previous current.

A current of 22 amperes in all three shunts produced 3.5 volts in the standard, and in breaking, 0.00 06 volt at the end of half a minute, which fell to 0.00 000 2 at the end of five minutes. The deflection was in the same direction as when the current was passing, and was reversed by reversing the current. The other shunts gave no such effects even with 60 amperes, so work was chiefly on this shunt. A current of 45 amperes caused an effect which sent the spot off the scale for over a minute.

Curves were plotted, showing the diminution of the thermal effect at equal intervals of time after stopping the main current, which show that while the current is passing the apparent resistance of the shunt is greatly increased by this action. It appears as if this counter electromotive force increased with the current, although not quite in the same proportion.

At this point my experiments had to be postponed; so all apparatus was put aside for a number of months, and then set up in exactly the same manner and position, with the exception that I only used the standard german-silver shunt, to which I added three new sets of terminals,—two of german silver and one of copper, all soft-soldered, using acid for a flux.

Experiments were made to find what caused the variable deflection from this shunt after a current had been passing, and to see if there was any noticeable difference in the materials used in the potential leads and solderings.

I designated the different sets of leads in the following manner:—

Leads No.	1	were of	german silver,	soft-soldered.	
" "	2	"	copper,	"	"
" "	3	"	german silver,	"	"
" "	4	"	copper,	silver-soldered	
" "	5	"	german	"	"

When the shunt was in air, the effects—due to thermo-electric action arising from the slight differences in temperature in the shunt itself previous to the passage of a current,—were found to be of such a magnitude as to be negligible in a shunt of so high resistance as this one, although far too great to be permissible in a shunt of a resistance corresponding to those generally used. These thermal electromotive forces varied both in sign and amount from zero to 0.00 000 12 volt, and having as an extreme variation about 0.00 000 24 volt. In this respect the german-silver leads were anywhere from two to five or more times as bad as the copper, and the two soft soldered ones seemed to be best, although not enough so to make any marked difference in the readings, which were very small at most. The difference between the copper leads was not appreciable.

With the shunt in air I allowed various known currents to flow for five minutes, and then took several series of readings, every quarter or half minute for about five minutes or longer, if necessary, to see what effect was produced in the shunt by the passage of the current. When the currents were only two or three amperes there was no effect produced large enough to notice; and as I could readily detect an electromotive force greater than 0.00 000 04 volt the action, if any, must have been very small. With currents that produced a perceptible warming of the wire, I found a great variety of effects, differing even in the same set of leads at different times.

Curves were plotted, showing the effect produced by a current of 24.2 amperes in the shunt for five minutes. The sets of wires called No. 1 and No. 3 were made from the same piece of wire, and soldered at the same time with the same solder; and yet they vary in a very peculiar way, for which I have no explanation except that the composition of the german-silver shunt has been acted upon by the solder used, and that in the short length (about two inches near each end), where the soldered joints are, the metal is not homogeneous.

The greatest deflection shows the electromotive force to have been 0.00 002 volt. Both sets of copper wires act in a similar manner, and give curves which rise quickly during the first half minute, and then gradually drop. Terminals No. 5 give a curve which begins high and falls sharply, and recovers slightly only to fall again. The curves of No. 3 fall rapidly at first, then rise in a regular and very marked manner, after which a fall takes place. Terminals No. 1 do not give especially marked curves unless it be on account of the much smaller deflections than any of the other wires.

I next placed the shunt in water, and examined it the next morning before passing any current through it, and found a large deflection of 105 units, corresponding to 0.00 004 2 volt. There was a slight difference between the various leads, generally about 5 per cent, but all deflections were in the same direction. I was careful to see that all

parts of the shunt were under water, and that the soldered junctions were at nearly the same depth, but still the deflections remained. A current of 25 amperes was sent through the shunt to see if there would be a similar action to that when the shunt was in air, but upon connecting the galvanometer the deflection was entirely off the scale for five minutes, and lasted for an hour. I found that a current of less than an ampere in the shunt, but in the opposite direction, would reverse for a while the remains of the effect due to the 25 amperes. There was no apparent difference in the leads, and as the deflections were reversible by reversing the current, and always opposite to those produced directly by the current, I concluded that there was an electrolytic action caused by the current. The positive end of the shunt always turned black, and the negative end tended to become white. I found that by carefully timing duration and direction of currents, I could get a right deflection which would diminish and a left one begin, which would in turn give way to another right deflection, but I was not able to get four changes. With the soldered ends entirely out of water the actions were exactly the same; but the moment the *whole* shunt was out of water all action ceased, and the deflection became very small: even ten inches of submerged wire gave the deflection, though to a lesser degree, as did also a wet rag wrapped around the wire for a short length.

A current of less than an ampere would produce less than 0.2 volt at the terminals, yet I could get these effects by it, so that simple decomposition of the water was not the cause of the trouble, which it seems to me must be attributed to a "polarization" effect. Having found the cause of the strange deflections when the shunt was in water, I did not continue the experiments any longer. The reason the large german-silver shunt did not show such trouble is, probably, that it had been carefully shellaced when made, and was protected from the oxidizing action.

In the light of these experiments, it seemed desirable to plan a shunt and galvanometer for use in comparing currents ranging from 1 to 1000 amperes, which would not be affected by either thermal electromotive forces in its circuit or in the shunt itself. These data were assumed, and the galvanometer calculated.

Calibrating current to be 1 ampere.
Largest current to be 1000 amperes.
Resistance of shunt to be 0.001 ohm.
E. M. F. at terminals when calibrating 0.001 volt.
Largest observed thermal E. M. F. 0.00 000 8 volt.
Average observed thermal E. M. F. about 0.00 000 08 volt.
Galvanometer current when calibrating to be less than 0.001 ampere.
Galvanometer coils to be 25 ohms of german-silver wire.
Deflection to be 10 c. m. at 1.5 meters, or about 2°.
Earth's field alone to be used.
Required dimensions of galvanometer.

The field due to the coils must be 0.006 in order to produce a deflection of 2° where H is 0.1717. The current producing this field would be 0.00 000 4 absolute unit; 25 ohms of No. 18 B. & S. german-silver wire would be a length of 8,440 c. m.

$$\text{Then radius of coil} = \sqrt{\frac{8{,}440 \times 0.00\,000\,4}{0.006}} = 2.37 \text{ c. m.}$$

$$\text{Average length of a turn} = 2\,\pi\,r = 14.9 \text{ c. m.}$$

$$\text{Number of turns} = \frac{l}{14.9} = 566 \text{ or } 283 \text{ per spool.}$$

15 × 19 turns give a coil section 0.604 × 0.766 inch.

The galvanometer was made of a single copper casting, with two channels for the coils, 0.2 inch apart. Each channel was 0.77 inch deep, 0.61 inch wide, and had an inside diameter of an inch. If the galvanometer is much lower than 25. ohms, the variable plug resistance of an ordinary bridge will cause an error too great to be safely neglected when only the galvanometer, leads and plugs are in circuit. The reasons for the other numerical figures are almost self-evident.

The shunt itself I would make of thin sheet german silver, with either copper or german-silver end blocks, as was most convenient, but preferring copper. The lead wires to the galvanometer would be of copper, either soft or silver-soldered to the end blocks, and should go to a commutator very near the shunt itself, and the galvanometer circuit so arranged as to be easily disconnected from the shunt and placed in a mercury cup to close the circuit for the resistance measurement. I would prefer to measure the total resistance by a standard bridge always connected and kept at a constant temperature.

This kind of a shunt could easily be made so that there would be very little heating, and if shellaced, or protected from oxidation in any other manner, could be used in water, although some kind of oil would probably be better.

There should be suitable mercury cups arranged so that the current could be easily and quickly reversed in the shunt, or the shunt entirely disconnected from the circuit.

Rogers' Laboratory of Physics, January, 1888.

DISCUSSION OF THE PRECISION OF MEASUREMENTS.[1]

BY SILAS W. HOLMAN, S. B.

Assistant Professor of Physics, Massachusetts Institute of Technology.

(Continued from page 201.)

Best magnitudes. In using almost any instrument it will be found that, on account of the nature of its indications, its greatest accuracy is secured at a certain point or within a limited part of its range. In designing an instrument there will be a best proportion among its parts. In arranging the plan of an indirect measurement, there will be some magnitudes more favorable than others to be assigned to the various component measurements. Thus in general there will be best magnitudes, either actual or relative, of the components. For instance, current measurement by a tangent galvanometer, whose readings are taken from a circular scale of equal parts, is fractionally more precise at or about 45°;—a bar whose moment of inertia, I, is to be computed from its dimensions and weight, may have for a given value of I a best proportion between its length and diameter;—in the magnetometer there is a best ratio between the distances from the needle to the two positions of the deflecting magnet.

The problem therefore arises to determine what these best magnitudes are in any given case. This is but another and higher phase of the subject already presented. Instead of determining, as by "equal effects," the best values of the precision measures for given magnitudes of the components, we are now to determine the best magnitude of the component qualities for prescribed conditions in regard to the precision in their measurement, and to the relative or absolute magnitudes of the final result or one or more of the components.

These conditions are thus of two sorts, viz.: First, *Precision conditions, i. e.*, having given the absolute or relative precision measures δ_1, δ_2, etc. Second, *Magnitude conditions*; *i. e.*, having given the absolute values of the components M_1, M_2, etc., or of the final quantity and one or more of the components. To see more closely what this statement implies, consider that throughout all this subject, where we deal with the effect of errors of measurement, those quantities or components are treated as independent which are the subject of separate or independent measurement—not calculated from another. But quantities may properly be thus independently measured and treated which are not mathematically independent, but are "conditioned," so that one is capable of expression

1. Copyrighted, 1888, by S. W. Holman.—From *Technology Quarterly*.

in terms of another either with or without another independent quantity. The function expressing such a relation would then give an equation of condition which must be regarded in determining the "best magnitudes," though not needed in the simpler case of computing the precision of the result, or assigning the precision of components.

As examples of conditions let us take the following:—*a.* Required the best values of c, r, and t for measuring the electric energy, $W = c^2 r t$, expended in heating a conductor. Given as *precision conditions* $\delta c = 0.01$ ampere, $\delta r = 0.01$ ohm, $\delta t = 0.2$ sec.; *magnitude condition* $W = 5{,}000{,}000.$ units. Note that the quantities c, r, and t, are wholly independent except for the magnitude condition that W is fixed. The numerical solution is given subsequently under head of *solution of examples of best magnitudes.*

b. It is desired to construct to best advantage a right circular cylinder of brass, whose moment of inertia around a transverse central diameter is to be computed from $I = m\left(\frac{h^2}{12} + \frac{d^2}{16}\right)$ where $m =$ mass, $h =$ height or length of cylinder, $d =$ diameter of cylinder. The value of I is most easily determined by measuring directly m (by the balance), h and d, which would be treated as independent (independently observed) if we were discussing the precision of I. Now, in determining the best magnitudes of m, h, and d we must know first the precision conditions. Suppose the measurements show these to be,—δm negligible, $\delta h = \delta d =$ constant. Second, we must have the magnitude conditions,—which would vary with circumstances. Suppose that it is required that I shall be of a given amount. Then as δm is negligible, m may have any value consistent with the other requirements, and we have to find the best value of the ratio of h to d. But h, d, and m, although independently observed, are not mathematically independent; for $m = \frac{\rho \pi d^2 h}{4}$ where ρ is the density of the brass. Hence the magnitude conditions are $I =$ constant, and $m = \frac{\rho \pi d^2 h}{4}$. The algebraic solution is given subsequently.

Methods of solution of problems on best magnitudes may be reached in two principal ways. First, whatever the number of the components, provided that they are mathematically, as well as by observation, independent, we may show from the principle of least squares, as in deducing the formula XXI for "equal effects," that in the long run the best magnitudes of these components will be found by solving for them from either the general expression XXI or the proper special one from XXII to XXV. The solution will, of course, be made for values either absolute or relative of the components M_1, M_2, etc., under both the assigned precision conditions respecting δ_1, δ_2, etc., and the magnitude conditions. The method is intended for those cases involving three or more variables, and which cannot well be solved by the second method, about to be described. Its results are but approximate, and therefore will differ usually by a slight amount from those obtained by the second method, which is to be preferred for one or two variables. But it is to be remembered that a considerable departure from the best conditions will affect the precision but slightly, and that best values to 10 per cent. are usually more than sufficiently close.

Second, if the number of components is one or two, and if two, whether independent of each other or one a function of the other, we may solve more exactly by the usual process of finding minima by differentiation. (Todhunter's Differential Calculus, chapter on Maxima and Minima of Two Variables.) By this process the general plan of the solution would be this: Write by means of formulæ XIII to XX the expression for Δ or Δ^2 in terms of the δ's as given by the precision conditions. Simplify as much as possible, and find by differentiation the values of M_1, M_2, etc., which will make Δ a minimum.

The cases which arise in differentiating are as follows:—

1. Where $u = f(x)$, *i. e.*, where it is required to find the value of x which will make u a minimum, u being a function of x alone. Here, of course, the desired value of x will be formed from the familiar conditions.

$$\frac{du}{dx} = 0, \text{ and } \frac{d^2u}{dx^2} \text{ is } +. \qquad \text{XXIX.}$$

Inspection alone often suffices to solve this simple case.

2. Where $u = f(x, y)$, but x and y are *not* independent, but $y = \psi(x)$. In this, the most common case, the general solution is by the equation.

$$\left(\frac{du}{dx}\right) + \left(\frac{du}{dy}\right) . \ \psi'(x) = 0, \qquad \text{XXX.}$$

where the parentheses indicate that the differentiation with respect to the variable is made on the supposition that the other at the time remains constant; and where $\psi'(x)$ denotes $\frac{d\,\psi(x)}{d\,(x)}$. Of course there are further conditions to discriminate between maxima and minima, etc., which must be applied when inspection alone does not suffice. The expression XXX is solved for the best values of x, or of $x : y$, or of x and y, etc., as the case in hand may require.

It is often convenient, instead of employing XXX, to substitute directly for y its value $\psi(x)$, so that $u = f(x, \psi(x))$, and then to differentiate with respect to x and equate to zero, as in XXIX.

3. Where $u = f(x, y)$ but x and y *are* independent. In this case both conditions

$$\left(\frac{du}{dx}\right) = 0, \text{ and } \left(\frac{du}{dy}\right) = 0 \qquad \text{XXXI}$$

must be fulfilled. The parentheses indicate as in XXX. As before, the further conditions for minima have seldom to be considered, as inspection serves to discriminate in most cases.

Solution of examples of best magnitudes. 1. Problem previously stated at *a.* $W = c^2 r t = 5{,}000{,}000.$ Precision conditions: $\delta c = 0.01$ ampere, $\delta r = 0.01$ ohm, $\delta t = 0.2$ second. Magnitude condition: $W = 5{,}000{,}000.$

To find magnitudes of c, r, and t to make ΔW a minimum. Solving by equal effects (general expression XXI.)

$$\frac{dW}{dc}\ \delta c = \frac{dW}{dr}\ \delta r = \frac{dW}{dt} . \ \delta t$$

$$\frac{dW}{dc} = 2\,c\,r\,t, \quad \frac{dW}{dr} = c^2\,t, \quad \frac{dW}{dt} = c^2\,r.$$

$$\therefore\ 2\,c\,r\,t \times 0.01 = c^2\,t \times 0.01 = c^2\,r \times 0.2$$

$$\therefore\ r = \frac{c}{2} \text{ and } t = 10\,c$$

Substituting these gives

$$W = 5{,}000{,}000. = c^2 \times \frac{c}{2} \times 10\,c = 5\,c^4$$

$\therefore c = 32$ amperes, $r = 16$ ohms, and $t = 320$ seconds are the desired best magnitudes.

Or by the formulæ for factors (XXIV),

$$\left(\frac{\delta c^2}{c^2} = \frac{2\,\delta c}{c}\right) = \frac{\delta r}{r} = \frac{\delta t}{t} \therefore \frac{2 \times 0.01}{c} = \frac{0.01}{r} = \frac{0.2}{t},$$

$$\therefore r = \frac{c}{2}, \text{ and } t = 10c. \ \therefore W = 5\,000\,000 = c^2 \frac{c}{2} \times 10\,c = 5c^4$$

$\therefore c = 32$ amperes, $r = 16$ ohms, $t = 320$ seconds, as before.

2. Suppose a tangent galvanometer read by an index moving over a circle graduated to equal parts. The precision measure, $\delta\,\varphi$, of deflection readings will be the same at all parts of the scale. Let φ be any reading, and K the galvanometer factor, the current is given by $C = K \tan\varphi$. Required the value of φ at which the errors of reading will have least effect, *i. e.*, for which $\frac{\varDelta C}{C}$ will be a minimum.

Precision condition : $\delta\,\varphi =$ constant.

Magnitude condition : none,

By xv.

$$\frac{\varDelta C}{\varDelta \varphi} = K \frac{d \tan \varphi}{d \varphi} = K \sec^2 \varphi, \quad \therefore \frac{\varDelta C}{C} \frac{2 \varDelta \varphi}{\sin 2\varphi} \qquad \text{XXXII.}$$

By XXIX the value of φ, which will make $\frac{\varDelta C}{C}$ a minimum, is to be obtained from

$$\frac{d}{d\varphi}\left(\frac{\varDelta C}{C}\right) = o \;\therefore\; \frac{d}{d\varphi}\left(\frac{1}{\sin 2\varphi}\right) = \frac{d}{d\varphi}\left(\operatorname{cosec} 2\varphi\right)$$

$$= -\frac{\cos 2\varphi}{\sin^2 2\varphi} = o.$$

Hence— $\frac{\cos 2\varphi}{\sin^2 2\varphi} = 0$, $\therefore -\cos 2\varphi = 0$, and $\varphi - 45°$, as, indeed, might have been seen at once from inspection of XXXII.

3. It is desired to construct a circular brass cylinder of given mass, m, whose moment of inertia around a central transverse diameter may be determined by measurements of its mass and dimensions with as great accuracy in units as possible. $I = m\left(\frac{h^2}{12} + \frac{d^2}{16}\right)$, where $h =$ height or length and $d =$ diameter.

Precision conditions : $\delta\, m$ negligible, $\delta\, h = \delta\, d =$ constant. Magnitude conditions : $m =$ constant, and $m = \frac{\rho \pi d^2 h}{4}$ where $\rho =$ density of brass = a constant.

From XIII. we find

$$\varDelta^2 I = \frac{m^2 h^2}{36} \cdot \delta^2 h + \frac{m^2 d^2}{64} \cdot \delta^2 d \text{ or as } \delta h = \delta d$$

$$\varDelta^2 I = \frac{m^2}{4}\left(\frac{h^2}{9} + \frac{d^2}{16}\right) . \;\delta^2 h$$

We have now to find the value of $\frac{h}{d}$, which will made $\varDelta I$ a minimum. Now $\varDelta I$ is a minimum when $\varDelta^2 I$ is so, and therefore (rejecting constant factors) when $\frac{h^2}{9} + \frac{d^2}{16}$ is so. Now h and d are not mathematically independent, because m is fixed, but from above value of m, $d^2 = \frac{4\,m}{\rho \pi h}$.

The case, therefore, falls under XXX, and we have

$$u = \frac{h^2}{9} + \frac{d^2}{16}, \; x = h, y = d, y = \psi(x) = \sqrt{\frac{4\,m}{\rho \pi h}}$$

$$\left(\frac{du}{dx}\right) = \frac{2h}{9}, \; \left(\frac{du}{dy}\right) = \frac{d}{8}, \; \psi'(x) = -\frac{d}{2h}$$

$$\therefore \frac{2h}{9} - \frac{d^2}{16h} = o \;\therefore \frac{h^2}{d^2} = \frac{9}{32}, \text{ and } \frac{h}{d} = \pm 0.53$$

Or we may solve by the second way previously suggested, as follows :

$d^2 = \frac{4\,m}{\rho \pi h}$ $\therefore$ substituting this in $\frac{h^2}{9} + \frac{d^2}{16}$ we have $\frac{h^2}{9} + \frac{4\,m}{16 \rho \pi h}$ to be made a minimum. Solved by XXIX.

$$\frac{d}{dh}\left(\frac{h^2}{9} + \frac{4\,m}{16 \rho \pi h}\right) = \frac{2h}{9} - \frac{4\,m}{16 \rho \pi h^2} = o$$

Restoring now for $\frac{4\,m}{\rho \pi h}$ its equivalent d^2, we have

$\frac{2h}{9} - \frac{d^2}{16h} = o$, whence as before $\frac{h}{n} = \pm 0.53$.

4. Problem previously stated at b.

Precision conditions : $\delta\, m$ negligible, $\delta\, h = \delta\, d =$ constant.

Magnitude conditions : $I =$ constant, $m = \frac{\rho \pi d^2 h}{4}$, ρ = constant.

The problem is similar to 3, but the value of I is now determined in advance instead of m, and it is desired to construct the bar so that I may be found with as great fractional accuracy as possible, which as I is fixed will be when $\varDelta I$ is a minimum. We will solve first by finding the minimum by differentiation.

The value of $\varDelta^2 I$ is as in 3, but m is now not fixed, so that h and d are independent of each other. We have not to adjust the magnitude of m, because whatever this may come out, $\delta\, m$ is negligible. But m is a function of h and d and ρ, and as it is not constant we must substitute for it the value $\frac{\rho \pi d^2 h}{4}$ before differentiating with respect to h and d, in order to fulfill the magnitude condition respecting I and ρ. We have now to find the value of $\frac{h}{d}$, which will make $\varDelta I$, and hence $\varDelta^2 I$, a minimum. Hence, substituting for m and removing constant factors $\frac{d^4 h^4}{9} + \frac{d^6 h^2}{16}$ must be a minimum.

This case, as h and d are independent, falls under XXXI, and

$$\frac{du}{dh} = \frac{4 d^4 h^3}{9} + \frac{d^6 h}{8} = o, \text{ and } \frac{du}{dd} = \frac{4 d^3 h^4}{9} + \frac{3 d^5 h^2}{8} = o.$$

Equating these, dividing by d^7 and transposing, gives

$$\frac{h^3}{d^3} - \frac{h^2}{d^2} + \frac{27}{32} \cdot \frac{h}{d} - \frac{9}{32} = o$$

This by approximate solution yields $\frac{h}{d} = 0.47$ as the desired ratio. [Methods for approximate solution of such equations may be found in some works on algebra ; *e. g.*, Wells' University Algebra, page 417.]

This fourth problem may also be solved, of course, by the condition of equal effects, but, as already stated, the result may not be precisely the same as the more exact one just obtained.

$$I = m\left(\frac{h^2}{12} + \frac{d^2}{16}\right) = \frac{\rho \pi d^2 h^3}{48} + \frac{\rho \pi d^4 h}{64}$$

As $\delta\, m$ is negligible and ρ is constant,

$$\frac{dI}{dh} \cdot \delta h = \frac{dI}{dd} \cdot \delta d, \text{ and as } \delta h = \delta d, \; \frac{dI}{dh} = \frac{dI}{dd} .$$

$$\frac{dI}{dh} \frac{\rho \pi d^2 h^2}{16} + \frac{\rho \pi d^4}{64}, \text{ and } \frac{dI}{dd} = \frac{\rho \pi d h^3}{24} + \frac{\rho \pi d^3 h}{16}$$

Equating and transposing gives

$$\frac{h^3}{d^3} - \frac{3\,h^2}{2\,d^2} + \frac{3\,h}{2\,d} - \frac{3}{8} = 0$$

This, by approximate solution, yields $\frac{h}{d} = \frac{1}{2}$ approx. as the desired ratio. This solution by equal effects is not intended, as has elsewhere been stated, for application where the ordinary differentiation will apply, but for cases with three or more variables.

Investigation of special problems. As further illustrations of the application of the foregoing methods, and to illustrate the way in which any considerable investigation presents for solution its own special line of problems, the following discussions are given.

Cradle dynamometer. The principle and operation of the Brackett cradle dynamometer are known to electricians. The cradle consists of a platform suspended at each end from a horizontal knife-edge, both having their edges in the same line. If the rate at which mechanical work is put into a dynamo is to be measured, the dynamo is placed upon the platform with its axis of rotation as nearly as possible in the line of the knife-edges. The centre of gravity of the whole system is brought up close to the same line by means of counterpoise weights above the edges. The rotatory moment applied to the machine is counterbalanced by a known weight, w, applied at a known distance, l, along a horizontal arm rigidly attached to the cradle; and the number, n, of rotations per minute of the dynamo shaft is counted. We have thus to measure three quantities, w, l and n. But a study of the reliability of the cradle dynamometer involves more than the consideration of the exactness with which the quantities w, l and n can be observed. The general action of the instrument must be considered to see whether there are in its adjustment or action, during or before a run, any causes which might tend to produce errors, whose existence might perhaps not be indicated by the action of the apparatus at the time. A discovery of such would lead to their study with a view to finding the conditions governing the design or use of the dynamometer.

It is, of course, impossible to maintain the dynamometer absolutely at its normal position at all times during measurement; *i. e.*, to keep its pointer at the zero or fiducial mark. It is therefore essential that the centre of gravity of the whole system should be sufficiently near the line of the knife-edges, so that the failure to adjust to zero during a run shall produce a sufficiently small effect; that is, it is necessary that the system, like a balance in weighing, shall have a sufficient sensitiveness. If the axis of the dynamo shaft were adjusted as nearly as possible to the line of the knife-edges, with the belt off, still on putting the belt on for a run, there would be introduced by the belt-pull a moment of rotation about that line, because the adjustment could not be absolute. We must therefore find whether by making the zero adjustment with the belt on, thus counterpoising this erroneous moment in large part, we may sufficiently eliminate its effect. Then there arises the very important question as to the rigidity essential in the whole system. Under the belt-pull the shaft axis and the centre of gravity of the whole system must be somewhat displaced. How small must this be in order to be of no sensible effect; that is, how rigid must the system be in order that the erroneous moment introduced either by the belt-pull acting through the displaced axis, or by the great weight of the whole system acting through its displaced centre of gravity, may be negligible or of the same effect as the other unavoidable sources of error. These and some other points will be now developed. In order, however, to make the problem cover a fairly illustrative case of use of the dynamometer, it will be stated as follows:—

Desired to one part in 100 the efficiency of conversion, E, of a 60 incandescent light shunt dynamo, the measurements of power to be made by the cradle dynamometer. Given in advance the rough values:—current $= c = 60$. amp.; volts at terminals of dynamo $= v = 75$. volts; resistance of armature $= r_a = 0.003$ ohms; resistance of field coils $r_f = 20$. ohms; number of rotations of armature per minute $= n = 1400$.; length of fixed arm for weights $= l = 3.4$ ft.; diameter of dynamo pulley $= 2R = 10$ inches; weight of dynamo + dynamometer $= P = 3{,}000$ lbs.; efficiency of conversion $= E =$ about 90 per cent. Required the closeness necessary in the component measurements and in the adjustments, and a study of the rigidity necessary in the whole system. How far should π be carried in the computation, and how closely should the factor (746) for reduction of volts to horse-power be computed?

Let L denote the total rate of electrical output in horse-power, and W the rate of application of mechanical power.

Then $E = \frac{L}{W} = 0.9$. For shunt machine,

$$L = \left(c\,v + c^2\,r_a + \left(\frac{v}{r_f}\right)^2 r_f\right)\frac{1}{746} = 6.4 \text{ h. p. approx.}$$

In the parenthesis $c^2\,r_a$ is written for $c^2_a\,r_a$, as being a sufficiently close approximation.

Whence $W = 7.1$ h. p. approx. And as $W = \frac{2\,\pi\,l\,n\,w}{33000.}$, we find $w = 8$ pounds.

It will be convenient if we can separate mechanical from electrical quantities in the discussion. This we may accomplish by assigning proper relative precision[1] to the factors L and W, and treating each by itself. Since each of these contain about the same number of observed quantities as the other, it will be sufficiently close to write

$$\frac{\Delta\,W}{W} = \frac{\Delta\,L}{L} = \frac{1}{\sqrt{2}}.\ \frac{\Delta\,E}{E} = \frac{0.01}{\sqrt{2}} = 0.007$$

Electrical—By general method. *N. B.*—In differentiating with respect to c, the term $c^2\,r_a$ may be dropped, since it is only $\frac{1}{460}$th of cv; and in differentiating with respect to v, the term $\frac{v^2}{r_f}$ may similarly be dropped.

$$\frac{d\,L}{d\,c} = \frac{v}{746} = 0.10;\ \frac{d\,L}{d\,r_a} = \frac{c^2}{746} = 5.;\ \frac{d\,L}{d\,v} = \frac{c}{746}$$

$$= 0.09;\ \frac{d\,L}{d\,r} = -\frac{v^2}{746\,r^2} = -0.02.\quad \Delta\,L = 0.007$$

$$\times\ 6.4 = 0.045;\ \frac{\Delta\,L}{\sqrt{3}} = 0.027,$$

using $n = 3$ because r_a may be neglected, as inspection will show.

$\delta\,c = 0.027 \div 0.10 = 0.27$ ampere, $\delta\,r_a = 0.027 \div 5 = 0.005$ ohms.

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1. Suppose $M = f\,(M_1,\ M_2, \ldots,\ M_r,\ M_s, \ldots,\ M_t)$ when all M's are observed quantities, and that $f\,(\,)$ is capable of separation into two (or more) factors each a function of observed quantities, so that

$$M = f\,(M_1, \ldots,\ M_t) = \varphi\,(M_1, \ldots,\ M_r).\ \rho\,(M_s \ldots,\ M_t).$$

Let r and p denote the number of quantities in $\varphi\,(\,)$ and $\rho\,(\,)$, respectively. Then for equal effects

$$\frac{\Delta\,\varphi\,(\,)}{\varphi\,(\,)} = \sqrt{\frac{r}{n}}.\ \frac{\Delta\ M}{M} \text{ and } \frac{\Delta\,\rho\,(\,)}{\rho\,(\,)} = \sqrt{\frac{p}{n}}.\ \frac{\Delta\ M}{M}$$

where $\frac{\Delta\,\varphi\,(\,)}{\varphi\,(\,)}$ and $\frac{\Delta\,\rho\,(\,)}{\rho\,(\,)}$ are the fractional precision of $\varphi\,(\,)$ and $\rho\,(\,)$, respectively.

$\delta v = 0.027 + 0.09 = 0.3$ volt, $\delta r' = 0.027 \div 0.02 = 1.4$ ohms.
Hence r_e may be neglected altogether, and r_f must be measured with coils at temperature attained during the run.

Also, $\frac{\Delta 746}{746} < \frac{1}{10} \cdot \frac{\delta L}{L} < 0.0007 \therefore \Delta 746 < 0.5$.

Mechanical.—By factors. $\frac{\delta l}{l} = \frac{\delta n}{n} = \frac{\delta w}{w} = \frac{1}{\sqrt{3}} \frac{\Delta W}{W} = 0.004.$

$\delta l = 0.004 \times 3.4 = 0.014$ ft. $= 0.17$ inch.
$\delta n = 0.004 \times 1400 = 5.6$ rota. p. m.
$\delta w = 0.004 \times 8 = 0.03$ lbs. $= 0.5$ oz.

$\frac{\delta \pi}{\pi} < \frac{1}{10} \cdot \frac{\delta w}{w} < 0.0004$, $\delta \pi < 0.0012 \therefore \pi = 3.142$ is sufficient.

Sensitiveness and index error.—The sensitiveness o the whole system to turn about the knife-edges is measured by the weight p (to be found by trial) necessary, when suspended at the distance l along the lever arm, to move the index from zero to one division of its scale. Suppose $n =$ average number of divisions unavoidable error in adjusting to zero or normal position during run. Then $\frac{n p}{w}$ is the fractional error in total weight w at l due to this source. To be negligible this must be less than $\frac{1}{10} . \frac{\delta w}{w}$ $\therefore p < \frac{1}{10} \cdot \frac{\delta w}{w} . \frac{w}{n}$. For the case in hand $w = 8$ lbs., and suppose $n = 0.25$ division (m. m.), and $\frac{\delta w}{w} = 0.004$, $\therefore$ $p = 0.0004 \times \frac{8}{0.25} = 0.013$ lbs. $= 0.2$ oz. This limit may be easily reached. Ten times this amount would cause an error of the same magnitude as $\frac{\delta w}{w}$.

Shaft to line of knife-edges, and zero adjustment.—How closely must this adjustment be made with the belt off? Let $2a =$ sum of tensions on two sides of belt. Assume for simplicity, at present, a parallel belt. Whether the belt is at rest or running the resultant pull is about the same in amount and direction; and as at time of weighing there is rotation without translation, there must be a resultant through axis of shaft equal to $2a$, and in same direction. If this axis is out of line of knife-edges by a perpendicular distance, d, there is on the dynamometer a moment not exerted in rotating the armature but still to be counterbalanced at l; *i. e.*, an erroneous moment, of amount $2ad \sin \theta$, where θ is the angle between direction of resultant belt-pull and direction of d, an angle equally likely to have any value. Let $R =$ radius of pulley on dynamo, $b = T - S =$ excess of tension of tight over slack side of belt. Then $bR =$ driving moment. Hence fractional error from imperfect adjustment, *i. e.*, ratio of erroneous to driving moment, is

$$\frac{a\, a\, d \sin \theta}{b\, R}$$

for which we must find a in terms of b. For leather belt on iron pulley $T + S$ cannot be more than about $\frac{5}{3}$ without excessive slip; and on tight dynamo belts it is likely to be much more than this. Hence

$$\frac{T}{S} = \frac{a + \frac{b}{2}}{a - \frac{b}{2}} = \frac{5}{3} \therefore a = 2\, b$$

as a least value, and $a = 5b$ would be nearer an average amount. Substituting the latter *under the assumption* that it is *constant*, *i. e.*, that the resultant belt-pull remains constant, gives

$$\frac{2\, a\, d \sin \theta}{b\, R} = 10 \frac{d}{R} \sin \theta$$

This, then, would be the fractional error if shaft were aligned with knife-edges, and dynamometer were brought to zero position with belt off, and *not* again adjusted with belt on, which would be the easiest, but, as will be seen, a very inexact procedure. In order that this error may become negligible,

$$10 \frac{d}{R} \sin \theta < \frac{1}{10} \cdot \frac{\delta w}{w} \therefore d < \frac{1}{10} \cdot \frac{\delta w}{w} \frac{R}{10 \sin \theta}.$$

Of course θ is always unknown. We may, therefore, solve for its average value $\frac{2}{\pi}$ or $\frac{2}{3}$ approx. In the present case $R = 5$ inches, whence $d = 0.0004 \times \frac{5}{10 \times \frac{2}{3}}$ 0.0003 inch, in order to be negligible, or 0.003 inch to be of same effect as $\frac{w}{w}$. Obviously either of these limits is utterly beyond reach, and hence the dynamometer *must* be adjusted to zero or normal position *with belt on and strained* to full tension at which it is to be run. If this were done the error would be fully compensated, *provided* that the belt-pull remained constant and the index were kept at zero at all times, and, also, that d remained constant,—a point to be considered later. But all of these provisions are impossible of fulfillment, and must, therefore, be further discussed. First, then, as index cannot be returned to zero at time of weighing within n divisions ($n = 0.25$ as already stated for this case), we must find how small d must be in order that this unavoidable error may be negligible. Moving index over n divisions will turn dynamometer through a small angle $\delta \theta$, such that $\delta \theta = \tan^{-1} \frac{n}{l}$. Now the change in erroneous fractional moment due to this will be

$$\frac{d}{d\theta}\left(10 \frac{d}{R} \sin \theta\right) = -10 \frac{d}{R} \cos \theta \therefore \delta \left(10 \frac{d}{R} \sin \theta\right) = -10 \frac{d}{R} \cos \theta . \delta \theta.$$

To be negligible this must be less than $\frac{1}{10} \frac{\delta w}{w} \therefore d < \frac{1}{10} \cdot \frac{\delta w}{w} \frac{R}{10 \cos \theta . \delta \theta}$.

For the case, in hand $n = 0.25$ mm., and $l = 3.4$ ft. $= 1040$ mm.

$$\therefore \delta \theta = \tan \theta = \frac{n}{l} = \frac{0.25}{1040.} = 0.00025,$$

and to be of negligible effect for average value, $\frac{2}{\pi}$, of $\cos \theta$

$$d < 0.0004 \frac{5.}{10 \times \frac{2}{3} \times 0.00025} = 1.2 \text{ inch.}$$

Thus so far as error from erroneous moment of belt-pull owing to imperfect zero adjustment is concerned, a very rough adjustment to line of knife-edges will suffice.

But the assumption that the belt-pull is the same when the belt is running as when stationary, and that it remains constant during a run,—apart from fluctuating changes which neutralize each other,—is one which persons familiar with leather belts in practice will not readily grant. Even under favorable conditions, the quantity $2a$, when the belt is running is liable to differ by several per cent. from its value when the belt is stationary. Hence we must see how this affects the admissible value of d. Let us compute the value of d, which would lead to a negligible error for a ten per cent. change in the total belt-pull. Obviously this would be ten times as great as the value found in the solution for the error due to the total belt-pull; *i. e.*, it would be

$$d' = 10 \times 0.0003 \text{ inch} = 0.003 \text{ inch},$$

or to be of same effect as $\frac{w}{w}$, $d' = 0.03$ inch. There are no sufficient data to determine whether a change of ten per cent. is unusual; but in my opinion it is not so. Any permanent change in belt-pull would be indicated by changed position of rest after the run. Thus the alignment of axis to knife-edges must be made with very great care, in order that the unavoidable errors may not be greater than those coming from δw, δw, etc., and it can hardly be rendered much smaller than these.

From the considerations of this section we then infer that

Dynamo shaft must be adjusted as nearly as possible to line of knife-edges.

Dynamometer *must* be adjusted to zero with belt on and tightened.

Belt should not be unduly tight.

Radius of dynamo pulley should be as large as possible.

Yielding of structure under belt-pull. Erroneous belt-pull.—The system of structure consisting of the dynamometer and the attached dynamo cannot be absolutely rigid. The belt-pull is large (200 to 500 lbs., say, in present case). Under this stress the structure is strained, and the shaft is thus displaced from the line of the knife-edges. Also, as the shaft is not an absolute fit in its journals, it may "climb" slightly in running, with an effect similar to the above. We have first to consider the erroneous moment due to the belt-pull, arising from this yielding. This problem is similar to the one solved in the last section. Let d be the amount of displacement of axis, measured at the pulley and normally to the line of the knife-edges. That part of d which is constant will be compensated by the adjustment to zero with the belt on. That part which is rapidly fluctuating will eliminate itself; and the component of d in the direction of the belt-pull will not be effective. Only the progressive change in d will enter into the result. To study the effect of this we have to differentiate the expression for the fractional erroneous moment with respect to d.

$$\frac{d}{d\,d}\left(10 \frac{d}{R} \sin \Theta\right) = \frac{10}{R} \sin \Theta.$$

Of course the tendency to greatest yielding will be in the direction of the belt-pull. But owing to the form of the structure, the direction of d will usually be more or less out of that line. The value of Θ would have no general average. Let us solve for $\Theta = 90°$. Then for case in hand, to be negligible,

$$\delta d < \tfrac{1}{10} \cdot \frac{\delta w}{w} \cdot \frac{R}{10 \sin 90°} < 0.00\,02 \text{ inch},$$

or 0.002 inch to be of same effect as $\frac{\delta w}{w}$. This shows the vital importance of great rigidity, and leads us to inquire in what direction the yielding will probably be least. A consideration of the form of the system shows that this will be the vertical direction. Hence the belt should be run vertically, and, preferably, downward. Thus

Whole system must be very rigid.

Belt should run downward from dynamo pulley.

Dynamo must be adjusted to zero, with belt on and tightened.

Yielding. Displacement of centre of gravity.—Let h be the horizontal and v the vertical component (referred to the dynamometer in its normal position) of the displacement D of the centre of gravity of the whole system under the belt-pull (or for any cause), D being measured perpendicularly to the line of the knife-edges. Let P represent the weight of the whole apparatus. The vertical displacement produces no effect except to slightly change the sensitiveness. The fractional error in the measured moment would be $\frac{P\,h}{w\,l}$, which obviously diminishes as the weight of the whole is less and as the value of $w\,l$ increases, *i, e.*, as the rate of output is larger. If the dynamometer is adjusted to zero with the belt on, then the constant part of this error is eliminated, and the error is reduced to $\frac{P.\delta h}{w\,l}$ when δh represents the permanent or progressive change in h, since fluctuating changes eliminate themselves. To be negligible,

$$\delta h < \tfrac{1}{10} . \frac{\delta w}{w} . \frac{w\,l}{P}$$

In the present case this gives

$$\delta h < 0.0004 \times \frac{8 \times 3.4}{3{,}000} = 0.00\,000\,4 \text{ ft.} = 0.00\,005 \text{ inch},$$

or 0.0005 inch in order to be of same effect as $\frac{\delta w}{w}$. Obviously this would require enormous rigidity of construction and attachment with a belt running in any other direction than that (downward) of greatest resistance, and very great resistance in that case. Hence,

Very great rigidity of construction and attachment in every part is essential in accurate work with a cradle dynamometer.

Belt should run vertically downard from dynamo pulley.

The greater the output and the smaller the weight of the apparatus, the better the result.

It would obviously be of decided advantage to drive the dynamo by means of a *couple without thrust* upon the axis if possible.

Position of centre of gravity.—To find experimentally the distance x of the centre of gravity below the knife-edges: Use letters with former significance, then $p =$ weight at l necessary to tip system through such small angle φ that the index moves over one division of the scale. Then

$$P x \tan \varphi = p\,l,\ \tan \varphi = \frac{1}{l} \therefore x = \frac{p\,l^2}{P}$$

For case in hand, suppose p to have been found by trial as 0.1 oz. = 0.06 lbs., when system was in adjustment. Then

$$x = \frac{0.06 \times 1040.^2}{3000.} = 22. \text{ mm.}$$

Tangent galvanometer. It is of importance to know the closeness necessary in the component measurements, in

the corrections, in the adjustments, etc., necessary in the tangent galvanometer of the form ordinarily employed in the laboratory. The following discussion affords not only this knowledge, but a basis for computing the dimensions of such an instrument for any desired work. The galvanometer here discussed is of a type having a single coil of n turns; radius $r = 20$ cm., about; breadth $= 2b = 2$ cm., about; depth $= 2d = 2.4$ cm., about; needle, with distance between poles, $= 2l = 1$ cm., about, suspended by single silk fibre (coeff. torsion $= \Theta$), and carrying glass index read to 0°.1 by estimation on circle of about 10 cm. diameter, parallax error being reduced by use of mirror. The expression for the current is, in its simple form,

$$C = \frac{10\,H r}{2\,\pi\,n}.\tan\varphi.$$

But the second member requires several corrections and assumes several adjustments to be properly made. The corrections may be introduced in the form of factors, so that the whole may most readily be treated by the method of factors. These factors will be indicated as we go on, and will be denoted by m_1, m_2, etc. The solution will be made to find the closeness necessary in the components, adjustments, etc., to produce *separately*

$\frac{\delta\,C}{C} = 0.001$. The attainable closeness will also be considered.

$m_1 = \frac{10}{2\,\pi}$ is a numerical factor which should, of course, be taken to $\frac{\delta\,m_1}{m_1} < \frac{1}{10} \times 0.001$ whence π should be taken to 3.1416.

$m_2 = H = 0.17$ abt. $\therefore \frac{\delta\,H}{H} = 0.001 \therefore \delta\,H = 0.002$ abt.

The measurement of H with this precision is difficult; and diurnal and local variations are of about this order of magnitude, though the latter may be much larger. The nature and magnitude of the errors entering into the measurement of H depend so entirely upon the method and instrument employed that they will not be here discussed. It will be assumed that H can be found to less than

$\frac{\delta\,H}{H} = 0.003$. It should be remembered that *relative* measurements of C are independent of the absolute value of H, and are subject only to the variations in H during the measurements.

(*To be continued.*)

TROUVE'S AUXANOSCOPE.[1]

In view of the great usefulness of pictorial illustration in elucidating technical discussions in the meetings of scientific societies and in proceedings in courts, everybody interested in such matters will welcome new devices for simplifying such illustration.

Hitherto, for the most part, recourse has been had to projection, either by oxyhydrogen light, or by a voltaic arc. For this a projecting lantern is necessary, as well as a suitable supply of light, and (a more important matter) prepared glass slides to make the projections. It will be easily understood that very often the most eager for discussion shrink from this expense and inconvenience. Mr. Trouvé has designed a very simple little apparatus called the auxanoscope, intended to reduce the difficulty of such illustrations. It is composed (figure 1), of two cylindrical tubes joined at a determined angle, one of which has at its extremity a parabolic reflector with a suitable source of light placed in its focus, and the other an ordinary photographic objective.

At the apex of the angle formed by the two tubes the object or picture to be projected is placed, perhaps a photograph, a design upon paper, a diagram, or the like.

This design, or object, receives the luminous rays thrown out by the light in the focus of the reflector, becomes luminous itself, and forms its focus at some distance before

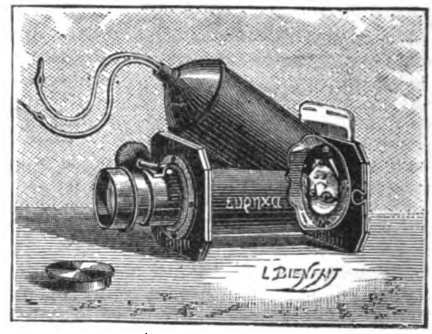


FIGURE 1.

the objective, which latter is arranged in a tube with grooves so as to admit any lengthening necessary. To obtain these effects there is no need of using a very powerful source of light; an ordinary incandescent lamp of several candle power, fed by a suitable number of cells of bichromate battery is sufficient to give satisfactory

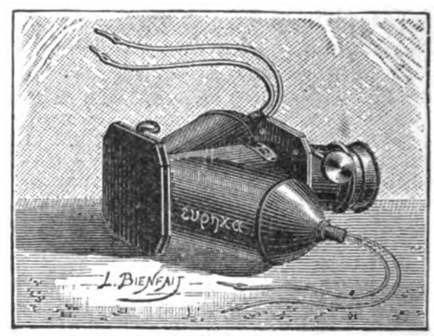


FIGURE 2.

results. Finally, to augment still further the effects produced, Mr. Trouvé has arranged (figure 3), on the other side of the central tube, a third similar to the first, and furnished like it with an incandescent lamp placed in the focus of a second parabolic reflector.

This apparatus may be applied to opaque bodies, which are thus lighted up in front. For transparent substances

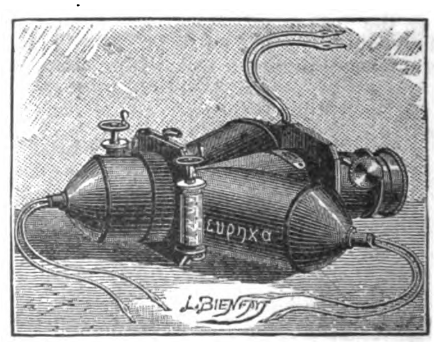


FIGURE 3.

a small reflector is applied on the extension of the tube containing the objective, and lights the substance by transparency. This little arrangement, called the *electric auxanoscope*, from its simplicity, will certainly be appreciated for demonstrations made in public, and also must replace advantageously the *old magic lantern* of our fathers.

1. Translated and abridged from *L'Electricien* of April 14th, 1888.

ABSTRACTS AND EXTRACTS.

ELECTROLYSIS OF IRON SALTS.

BY ALEXANDER WATT.

(Continued from page 261.)

Magnesio-Citrate of Iron.—The electrolyte was formed by dissolving freshly precipitated carbonate of iron in a strong hot solution of citric acid and then adding hydrated carbonate of magnesia until the solution was nearly neutral. The liquid, when cold, was diluted with about twice its bulk of water. With a current from two Daniells a good deposit of iron, but of a greyish white color, was at once obtained upon a copper plate. After a short immersion the coating became streaky and of a dark color; two more cells were then connected, and an addition of citric acid made to the bath, when the character of the deposit was greatly improved, and it soon assumed a fairly good white color, and adhered well to the copper surface. This solution, however, like the sodio-citrate, is inferior to the simple protocitrate, from which much better results can be obtained.

Borate of Iron.—To prepare a solution of this salt a quantity of freshly precipitated and moist carbonate of iron was digested for some time in a nearly boiling solution of boracic acid. Although the carbonate is but sparingly soluble in this acid, the resulting solution, when diluted with about twice its bulk of water, formed an electrolyte from which a good bright deposit of iron was obtained upon both sides of a copper plate immediately after immersion. The current from five Daniells was used, and the surface of the electrodes was about equal. During the electrolysis the anode kept perfectly bright and clean, and the deposit maintained a uniformly bright surface throughout the trial. It should be mentioned that an excess of boracic acid was given to the liquid.

Sulphates of Iron and Soda.—A solution of the mixed salts was prepared by adding to a solution of sulphate of iron (one ounce of sulphate in 10 ounces of water) about an equal quantity of a solution of sulphate of soda. With the current from five Daniells, and about equal electrode surface, a fine white and uniform coating of iron was obtained upon a copper plate a few seconds after immersion, and the deposition proceeded with perfect uniformity and with great rapidity, a good coating being received upon the plate in about a quarter of an hour. It seems probable that a bath prepared from these salts, with such modification of density as a larger trial might suggest, would prove a useful electrolyte for depositing iron for practical purposes. A second plate was next placed in the bath and allowed to remain for a longer period, when, as before, a perfectly uniform deposit was obtained, while the anode still retained its brightness, and exhibited signs of having been freely acted upon. On examining the solution (which was faintly acid) after the trial there was no evidence of oxidation on its surface. It should be mentioned that the deposit took place on both sides of the cathode, the back of the plate being fairly coated with iron a few seconds after immersion, indicating that this bath is a very good conductor. In many of the solutions of iron salts which I have electrolyzed during these experiments, the front of the cathode—that is, the surface facing the anode—alone received a deposit of metal, while in some instances there was only a partial disposition for the metal to deposit on the back of the plate. In several instances the film positively refused to make its appearance on this surface of the negative electrode. In the present case the deposition commenced at the bottom of the plate and continued upward, which, as I have shown, is not always the case; indeed, I have known many instances in which it has been practically impossible to obtain a coating of metal upon the corners and lower edges of the cathode, even when the upper part of the plate has been coated with metal. When this peculiarity shows itself, however, it is a sure sign that the solution is an indifferent conductor.

Pyrophosphate of Iron.—A solution of this salt was prepared as follows:—A moderately strong solution of the pyrophosphate of soda was first obtained, and into this was poured, gradually, a solution of persulphate of iron. The mixture being well stirred, the resulting precipitate rapidly became dissolved, when fresh additions of the iron salt were added to nearly the point of saturation. The solution thus obtained was worked with five Daniells. In a few moments there was a moderate evolution of gas, and a dark brown salt became formed at the cathode. The plate after remaining in the bath for about five minutes was examined, when a dark blue horizontal streak of iron appeared on its upper surface, but no metal had deposited upon the remainder of the plate. On raising the anode it was found to be covered with a thick white and dense mass, which had apparently stopped the passage of the current. Beyond these effects no result could be obtained from this solution.

Chlorides of Iron and Magnesium.—To prepare this bath a solution of acid protochloride of iron was first neutralized with carbonate of magnesia and then filtered. The clear liquor was then electrolyzed with the current from three small Daniell cells, in series, when a dark bluish-grey film was immediately obtained upon a brass cathode. Two cells were next tried, when, as before, the deposit took place instantaneously; the solution was now diluted and a fresh plate immersed. The deposition being still too quick, however, more water was added to the bath, when the character of the deposit improved. The current from a single cell was next tried, with still further advantage, since the film now became whiter and more bright. With the single cell there was but little evolution of gas, but in a short time the liquid became murky. A moderate addition of a solution of chloride of magnesium was now made, and the solution well stirred, when it at once became light and clear. A freshly prepared brass plate was then immersed, which soon became coated with a film of iron of a good white color and very adherent. The deposition being still rather more speedy than was desirable for a good reguline and tenacious deposit, the anode surface was reduced to about equal that of the negative electrode, when the deposit took place more gradually, and the character of the film greatly improved. There was, however, considerably more gas eliminated after the addition of the magnesium salt, and the hydrogen bubbles had a tendency to rest upon the plate.

Chlorides of Iron and Sodium.—A moderately strong solution of the protochloride of iron was first made, and to this was gradually added a strong solution of carbonate of soda, until the liquid was neutral to litmus paper. With the current from three Daniells, and large anode surface, a partial film of iron slowly formed on the brass cathode, and at the same time a white gelatinous deposit appeared on the plate, which was ejected from the surface by the hydrogen (which was very copious), and finally deposited at the bottom of the vessel. A few drops of hydrochloric acid were now added to the liquid, when the solution became clear; the anode surface was also increased, when a bright film of iron slowly formed upon the plate. The solution was next diluted with about double its volume of water, and a small quantity of common salt added and dissolved in the liquid, when the deposition immediately improved in every way, being not only more rapid, but the film became perfectly bright, and of a brilliantly white color. It was found necessary now, however, to reduce the anode surface considerably, little more than half that of the cathode being sufficient. It was next determined to reduce the number of cells, one and two cells respectively being tried; but the most suitable current was obtained from the latter number of cells in series, and equal electrode surface, with which a fine white and remarkably bright and adherent film was obtained at a fair rate of deposit. Although this solution of the mixed salts is capable of yielding very favorable results, it is scarcely one that could be recommended for practical working, inasmuch as it might be somewhat uncertain in its performance as an electrolyte, unless the current and anode surface were regulated, as we have seen, to a degree of nicety that is scarcely so necessary with some of the solutions described in the former papers of this series.

Nitrates of Iron and Potassa.—This bath was prepared by adding to a solution of protonitrate of iron one of nitrate of potassa, the compound solution being of moderate strength. The current from a single Daniell cell was first tried, when a dull, opaque film of a non-metallic character—probably a subsalt of iron—was obtained upon the cathode. Two cells were next tried, with similar results. A third cell was then connected in series, when after a short immersion of a brass cathode, a dark green salt formed upon its surface, and in about two minutes after accumulated on the plate as a green spongy mass, finally falling off the surface and depositing at the bottom of the vessel. This green salt, when exposed to the air, oxidized with great rapidity, forming a rusty compound of somewhat brighter color than ordinary rust of iron. No metallic deposit of iron could be obtained from this bath with any modification that suggested itself, either in strength of current or density of the liquid, so the experiment was abandoned. It should be mentioned, however, that the dark green salt referred to sometimes formed an adherent film—apparently transparent—which could only be detached from the plate by force, while the remainder of the same material, which formed the upper layer of the deposit, came away from the plate spontaneously, or was easily removed by wiping it off with the finger. I may mention the fact that I have frequently met with the same dark green, semi-adherent substance when electrolyzing some of the persalts of iron.

Iodide of Iron.—This salt was first prepared by digesting fine iron wire in warm water, to which was added a quantity of iodine, the containing vessel being repeatedly shaken at intervals of an hour or so, and then allowed to repose until the following day, by which time the iodine had disappeared, and the solution was ready for use. The liquid, which had a greenish tint, was moderately diluted with water, and then electrolyzed with two Daniell cells, when a film, of a blued steel color, was promptly obtained upon a brass cathode. A single cell was next tried, when the deposit was still very rapid, of a dark color and dull, but very adherent. After a time the solution became turbid from decomposition, and the experiment was then discontinued.

Ferrocyanide of Potassium and Iron (Soluble Prussian Blue).—A solution of this double salt was formed by adding a solution

of perchloride of iron to one of ferrocyanide of potassium, the latter being in excess. The precipitate of Prussian blue thus obtained was, after filtering, dissolved in water, and the resulting liquid then gently warmed and electrolyzed with a current from one, up to five, Daniells, but no deposit of iron could be obtained upon a brass cathode. The liquid was then heated to about 120° F., but with no better result, so the experiment was pursued no farther.

Tannate of Iron.—This electrolyte was prepared by cautiously adding a solution of tannic acid to one of perchloride of iron, avoiding an excess of the former. The black liquid thus obtained was then heated and electrolyzed with the current from four Daniells, when a slight metallic film was received upon a brass plate, but only in patches, while other parts of the plate became coated with a dark brown, tolerably adherent non-metallic film. A good deal of gas was liberated at both poles, which rested on the surface of the liquid in very large bubbles, and when the cathode was lifted out of the bath these came away with it and remained for some time upon its surface without breaking, a peculiarity before observed in respect of the electrolysis of the pernitrate of iron solution. The bath was now heated, but with little or no advantage, since nothing but a trifling deposit of iron, in parts of the plate only, could be obtained, while a gelatinous deposit formed upon the plate, indicating that the solution was gradually decomposing.

Gallate of Iron.—A solution of gallic acid was gradually added to one of perchloride of iron, and the blue black liquid thus obtained was electrolyzed with the current from four Daniells. The results were of a precisely similar character to the preceding, except that there was no actual film of metallic iron; the only deposit obtainable was a brown non-metallic film.

Potassio-oxalate of Iron.—A solution of this salt was prepared by Graham's method, namely, by dissolving hydrated peroxide of iron in a solution of binoxalate of potassa, a pale green solution being obtained, which was first electrolyzed with a single Daniell, when an opaque, white and firmly adherent insoluble salt was deposited upon the cathode. Three cells were then tried, when a tardy deposit of metallic iron, of fairly good color, appeared on the surface of a freshly prepared plate. The liquid was afterwards heated, and in this state it yielded a very white film of iron, which was firmly adherent. It is a singular fact that when the plate was first put into the bath after it had been heated, that the same opaque film, before noticed, at once appeared on its surface, but when the plate was allowed to rest undisturbed for a few minutes, this film disappeared, and the metallic deposit then occupied its place.

Pertartrate of Iron.—A bath was prepared from this salt by digesting recently precipitated and moist hydrated peroxide of iron in a boiling solution of tartaric acid. The resulting liquid, which, after filtration, was of a bright yellow color, was diluted, and then tried with a current from four Daniells, when there was a brisk liberation of hydrogen, but no deposit of metal appeared on the cathode. The strength of the current was then gradually reduced, until finally a single cell was tried, but without any result. The liquid was then heated, and the experiment repeated with the same variations of current strength, but only a slight film of iron could be obtained with the warm solution, four cells being used, by briskly moving the cathode about in the bath; when stationary, no deposit whatever could be obtained. It was next determined to try the effect of dilution, as I had previously found that metallic deposits could be obtained from highly attenuated solutions of persalts of iron, which were impossible with stronger liquids. Water was now added until the bath had become diluted to about 10 times its original volume. With four Daniells and increased anode surface, a bright film of metallic iron soon appeared upon a brass plate, except at the lower corners, where there was no deposit. Farther additions of water were afterwards given, a fresh plate being immersed after each addition, until the solution had become weakened to the extent of about 20 times its original bulk, when even in this very dilute condition films of metallic iron were obtained. The results of this experiment clearly show that under certain conditions of the electrolyte—extreme dilution, apparently being the most essential condition—solutions of iron persalts will give up their metal by electrolysis; and if this has hitherto been considered unattainable it must be evident that such necessary conditions have not been fulfilled by those who have experimented with these salts.—*The Electrician* (London).

(*To be continued.*)

ADVANTAGES OF ELECTRICITY FOR RAILROAD WORK.

THE rapid advances of the application of electricity to street car traction brings up the question whether we cannot in the near future look to the displacement of the steam locomotive by the electric motor. The conditions of street car and railroad work are different: in the first, electricity is called upon to displace horses, an extremely costly motive power; in the second, it must displace steam. That it can economically replace horses has been shown by a number of electric tramways at present in operation. The only question is, will considerations of safety and æsthetics allow the current to be economically conveyed to the cars? For instance: in the Sprague Electric Railway in Richmond, using an overhead conductor, it is costing for power about $1.70 per day per car, the cars averaging over 80 miles. This is for only 20 cars. When the full complement is running, the cost will be reduced, probably to about $1.50 per car per day. This cost is to be compared with the $5 or $6 that must be allowed per car per day for horses, at an average of, say, 60 miles per car per day. If the overhead system could be used, then, in all of our cities, there would be no doubt as to the results as far as street car traction goes. When it comes to ordinary railroad work, the state of affairs is very different. The question is, shall we substitute for steam, used directly, a power which is in the first place derived from steam, and which suffers the losses due to at least two transformations before it is utilized in driving the train? As far as mere economy of power production goes, the question is easily answered: the efficiency of a stationary steam plant is greater than that of a locomotive engine; and the cost of a horse-power delivered to the driving axles of the train by the electric motor would not be more for coal, attendance, and depreciation, than the same power from the locomotive, even after allowing for all the losses in the different transformations. The advantages of the electric motor are these: the driving machinery is the simplest that it is possible to conceive of: the armature of the motor would be fitted directly on the car axle, while the field magnets would rest on the truck. Each axle would have its motor, and in a train every second or third car would be a motor car. One advantage of this has been pointed out, first, probably, by Professor George Forbes. Taking a six-car train, we would have the traction, not of four wheels, but of 16, supposing two motor cars. This will enable us to make any speed that safety will allow, to start quickly, and to take at high speeds grades that at present are inadmissible. In fact, we can dispense with a great deal of the grading that makes the construction of railroad lines so costly. Again: on the down grades we can make our motors into dynamos feeding current into the line,—a plan due, I think, to Mr. Sprague,—instead of wasting energy by braking the wheels; and we can in the same way brake the cars when stopping. The advantages, then, are great simplicity, increased traction, allowing an increase of speed and a decrease in the cost of constructing the road, recovery of energy on down grades and in stopping. As compared with city electric tramways, such as are now in use, railroads would have the advantages of simplicity, in not requiring any gearing between the motor and car axle, and in allowing any economical means of conducting the current to the car, and the employment of high electromotive forces. There is one great disadvantage, however, that the future may remove, but which at present is serious. A station supplying any portion of the line will have to have a capacity equal to the maximum work that will be required of it at any time, while the mean work might be very much less than this. As the maximum may differ from the average work five or six times, we would have to equip stations of five or six times the present capacity of the locomotives, at a cost that would throw the balance in favor of the present system, unless there happened to be very considerable sources of natural power along the line. The remedy for this—a remedy which cannot be at present applied—is in equipping the stations with storage batteries; charging them when the required power is below the average, drawing from them when it is above. We may say, then, that with long-distance direct lighting and electric tramways, electric railways wait the development of a more perfect storage battery to be successful.—*Science.*

. . . . You might as well try to stop the sea as to stop the use of alternating machines.—*Gisbert Kapp.*

. . . . The Standard Oil Company have capable men whose only study is to reduce the cost of the output. We all know the result.—*The Millstone.*

. . . . If secondary batteries were good enough I should never dream of putting down alternating transformers, but I have never seen a good battery.—*Gisbert Kapp.*

. . . . You can get but a certain number of volts out of any combination of two substances, no matter what they are; you can calculate just the possible amount, in volts, and you can get no more.—*C. S. Bradley.*

. . . . A nation of 60,000,000 people, in whose territory are the finest copper mines, producing every year enough copper of the very best quality to supply the home demand, must now go on its knees to a speculator in Paris for the copper which it needs.

. . . . It is clear that in all directions distribution by means of transformers is the order of the day, and whether it be by alternating current machines on the one hand, or by accumulators on the other, or by motor-dynamos, it is clear that transformers will be the means of distribution.—*Silvanus P. Thompson.*

THE ELECTROMOTIVE FORCE OF MAGNETIZATION.[1]

BY EDWARD L. NICHOLS AND WILLIAM S. FRANKLIN.

AT the Ann Arbor meeting of the American Association for the Advancement of Science, we described some singular modifications in the relation of iron to acids which occur when the reaction takes place within the magnetic field. The present paper deals with the behavior of iron when that metal acts as one electrode in a voltaic circuit, and is at the same time subjected to magnetization.

A galvanometer placed in a circuit consisting of two electrodes of iron, metallically connected on the one hand, and dipping, on the other, into a cell containing any liquid capable of dissolving them, will indicate the existence of a current whenever the reaction between the metal and the liquid differs in character or rapidity at the two terminals. There are always at work a number of causes of such inequality of action, and the electromotive force between iron poles in any liquid which attacks them freely is not inconsiderable. It amounts as a rule to several thousandths of a volt; and even when special precautions have been taken to secure homogeneity in the elements of the circuit, a sensitive galvanometer will not fail to show the existence of a current. If one of the terminals be placed within a magnetic field, new differences of potential will be developed, both from the magnetization of the iron and from the change in the chemical relations between the metal within the field and the liquid. This electromotive force we have proposed to call *the electromotive force of magnetization.*

With the exception of two papers by Dr. Theodor Gross,[2] of Berlin, which came to our notice too late to enable us to take advantage of their valuable contents in our investigation, we know of no observations of the effect of magnetization upon the voltaic behavior of iron. Dr. Gross's research deals chiefly with the electromotive force due to the magnetization of the iron, and touches only incidentally upon the nature of the currents produced when one of a pair of iron electrodes has its electro-chemical relations to the solution modified by being placed within the magnetic field. It is with the latter phase of the subject, principally, that our experiments have to do.

The first form of cell, which we used, consisted of two glass tubes, *a* and *b* (figure 1), about 1^{cm} in diameter and 10^{cm} long.

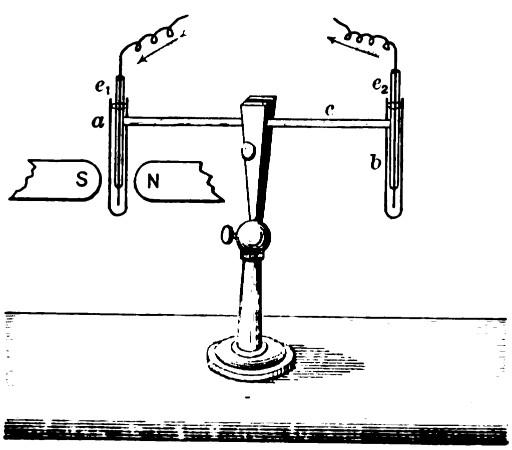


Fig. 1.

These were closed at the lower end and were connected by a narrower glass tube (*c*), about 50^{cm} in length. The electrodes, e_1 and e_2, consisting of soft-iron wire were inserted through the open ends of *a* and *b*. They were exposed to the liquid for about 1^{cm} at their lower ends. When this apparatus was filled with a liquid capable of dissolving iron, it formed a single cell, one terminal of which could be placed between the poles of an electromagnet, while the other was well outside of the field. When the free ends of the wires, e_1 and e_2, were connected through a sensitive galvanometer, it was found that, although the terminals were taken from the same piece of wire, and were immersed in the same liquid, a measurable current was always flowing in the circuit. The electromotive force was constant neither in amount nor in direction. In many liquids it changed but slowly, however, and could be balanced by means of a variable counter-electromotive force introduced into the circuit. For this purpose a Daniell's cell was placed in circuit with two variable resistances, R and *r* (figure 2). The cell with iron electrodes was shunted around *r*, and the ratio R/*r* was so adjusted that the current in the shunt circuit, due to the Daniell's cell, was just sufficient to reduce the galvanometer deflection to zero. The galvanometer could then be sensitized to any desired extent, but the fluctuations in the electromotive force of the iron cell were such that the balance was never more than momentarily maintained, and the galvanometer drifted continually.

In very weak acids and in solutions of $FeSO_4$, $FeCl_2$, NH_4Cl, and similar salts, these fluctuations were not such as to preclude the possibility of making measurements, but in concentrated acids they were for the most part so rapid and irregular as to put galvanometer readings out of the question. In nitric acid, of considerable strength, these fluctuations were so remarkable as to deserve special mention. The electromotive force, amounting to a considerable fraction of a volt, changed sign continually, carrying the spot of light across the galvanometer scale, to and fro, with great rapidity. The frequent and irregular oscillations con-

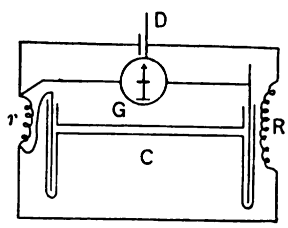


Fig. 2.

tinued with undiminished violence until the electrodes were entirely dissolved or the acid nearly neutralized. Upon first closing the circuit one of the iron terminals would be slightly more active than its fellow. The tendency of the less active electrode would then be to protect the other from the attack of the acid, rendering it temporarily passive, as a piece of platinum would do under the same circumstances. The passive terminal would then react in like manner upon the first, and electromotive force would be reversed again and again until the electrodes were consumed.

In those cases in which the fluctuations were not such as to make the attempt at compensation ineffectual, we were able to make measurements of the initial electromotive force of the cell and of the changes in electromotive force caused by the action of the magnet.

One of the iron terminals was placed between the poles of a large electro-magnet. To obviate any direct effect of the magnet upon the galvanometer needle, the galvanometer was set up in a room several hundred feet distant from that in which the former instrument was located. The "iron" cell having been connected with the wires leading to the galvanometer room, the initial electromotive force was balanced by the method already described, and the galvanometer was brought to the desired degree of sensitiveness by means of a governing magnet. One observer then proceeded to made galvanometer readings at intervals of 15 seconds, while another magnetized and demagnetized the electro-magnet every two or three minutes, reversing the magnetizing current each time. The electro-magnet in question has been described in a previous paper.

Like most large instruments of the kind, it required several seconds after the circuit had been closed to attain its full strength; and it retained considerable residual magnetism when the circuit was broken. By the following very simple device, however, the residual magnetism was almost entirely destroyed. A reversing switch of Poggendorff's pattern and an ordinary telegraph key were placed in series in the magnetizing circuit. While the magnet was in function, a piece of soft iron wire about 1^{cm} long was suspended by magnetic attraction from the underside of one of the pole-pieces. The wire served as an indicator of the magnetic condition of the poles. Upon breaking circuit with the key the residual magnetism was sufficient to hold it in position. When, however, the current was first reversed by means of the Poggendorff switch, and then broken at the instant when the magnet was passing through the condition of neutrality, the proper moment being indicated by the dropping of the suspended wire, the magnet was left thoroughly demagnetized. The interval of time between reversal of the current and neutrality was about two seconds.

After each series of readings, the galvanometer was calibrated, the resistance of the iron cell was measured and the strength of the magnetic field was estimated by a modification of Rowland's method. The instrument used in most of these measurements was Edelmann's form of the Wiedemann galvanometer, read with telescope and scale. For some experiments in which a high degree of sensitiveness was necessary a Thomson reflecting galvanometer of 2500 ohms resistance was used.

It was found possible by this method, excepting when the fluctuations in the initial electromotive force of the cell were very marked, to detect changes amounting to much less than .00001 volts.

We experimented with a variety of reagents, including nitric

1. Paper read at the New York meeting of the American Association for the Advancement of Science, August 11, 1887. From the *American Journal of Science*, vol. xxxv, April, 1888.

hydrochloric and sulphuric acids; ferrous sulphate, ferrous chloride, and ammonium chloride, in aqueous solutions, and finally, sulphuric acid, to which potassium bichromate had been added, and hydrochloric acid containing potassium chlorate. In every case there was unmistakable evidence of the development of a permanent electromotive force due to the influence of the magnet. The smallest effect, .000008 volts, was observed with terminals in concentrated nitric acid, the iron being passive—the largest effect in those solutions in which rapid oxidation took place. In a solution consisting of dilute sulphuric acid containing potassium bichromate, the electromotive force of magnetization amounted to .039 volts. In the same acid, the concentrated sulphuric acid of commerce diluted with 10 parts of water, without the addition of the potassium bichromate, it was only .0005 volts. Concentrated hydrochloric acid (sp. gr. 1.1768), gave .003 volts, the same acid, diluted with four parts of water, only .00002. When potassium chlorate was added to the dilute acid, the effect due to the magnet became very marked, amounting certainly to several hundredths of a volt; but the fluctuations in the initial electromotive force were such as to make readings impossible. In nitric acid diluted with nine parts of water the effect was also very large, but it was so masked by the initial fluctuations described in a previous paragraph, that no quantitative determinations were secured. The strength of field during these experiments was about 10,000 H.

In the hope of eliminating these fluctuations in the initial electromotive force, two modifications of our apparatus were made. In the first, it was so arranged that a current of the fresh solution passed through both arms of the cell, and the products of the reaction were carried away from the neighborhood of the terminals almost as soon as formed. In the second modification, terminals were prepared, the surface of which consisted of pure iron, electrolytically deposited. When these prepared terminals were used, the fluctuations were somewhat less marked than when the original surface of the iron wire was exposed, but the adoption of these two modifications led to no new results. A more important modification consisted in the substitution of platinum or copper for the iron terminal outside of the field. These metals being unaffected by the magnet, could be placed in close proximity to the magnetized terminal; the internal resistance of the cell was thereby greatly diminished and its form simplified. The iron-copper and iron-platinum cells were placed between the poles of the electro-magnet, and the investigation consisted in determining the electromotive force before and after the magnet had been made active. The most satisfactory results were obtained with a cell patterned after the Daniell battery—a two-fluid cell in which copper immersed in sulphate of copper was separated from the iron pole by a porous diaphragm, the iron being submerged in a solution of ferrous sulphate or of ferrous chloride. A cell of this description in which a neutral solution of ferrous sulphate surrounded the iron, and which possessed an initial electromotive force of .6072 volts, increased to .6361 volts when placed within the field. Similar results were obtained with other solutions.

In the various forms of apparatus already described the currents due to magnetic action did not always flow in the same direction. The iron terminal within the field would sometimes act as zinc toward the unmagnetized electrode, sometimes as platinum. To determine the law governing the direction of the currents due to the electromotive force of magnetization we tried the following experiments. The terminals of iron wire used in our original apparatus were supplanted by cylinders of soft Norway iron 1^{cm} long and 4^{mm} in diameter. These were placed horizontally in the solution and were attached to the end of copper wires. The wire was in each case thoroughly insulated from the liquid, and the iron bar itself was protected by a coating of wax with the exception of a single portion of its surface, which to the extent of a few square millimeters was exposed to the action of the liquid. Under these conditions, the direction of the electromotive force developed between the terminal within the field and a similar one outside was found to depend upon the portion of the bar exposed and the position of the latter with reference to the lines of force. Whenever the exposed surface was in the neighborhood of an induced pole within the soft iron electrode it became in its relations to iron outside of the field, as zinc to platinum. Whenever, on the contrary, the exposed surface was situated in a neutral portion of the bar, it became as platinum in its relations to unmagnetized iron. When platinum, carbon or copper was substituted for the unmagnetized electrode the electromotive force of the cell thus formed was increased by magnetization, in the case in which a pole of the iron terminal was exposed to the liquid and diminished by magnetization when the surface acted upon lay in the middle of the bar. A reversal of direction in the current flowing between such a bar of iron in the field, one end of the bar being exposed to action, and an unmagnetized iron terminal, could be produced by turning the former in the field. When the axis of the bar was parallel to the lines of force and it was accordingly magnetized longitudinally, it acted as a zinc pole, the current flowing from its surface through the cell to the unmagnetized electrode. When turned through 90° upon an axis perpendicular to the line joining the poles of the electro-magnet, the bar became magnetized transversely and the direction of the current was reversed.

Between bars lying with their axis parallel to the lines of force, the end of one and the middle of the other of which was exposed, the effect was more marked than between either of them and a piece of unmagnetized iron; the bar with exposed pole acting as zinc, that exposed in the middle as platinum.

After having determined the conditions which govern the direction of the current, we turned our attention to the relation between the strength of the magnetic field and the electromotive force which it is capable of producing. The cell selected for this work was an iron-platinum element, containing a solution of potassium bichromate in dilute sulphuric acid. In this liquid the electromotive force of magnetization was so marked that when the cell was placed between the pole-pieces of the electro-magnet the influence of the residual magnetism of the latter upon its electromotive force could easily be detected. Measurements were made in fields varying in intensity between 2,000 H., and 20,000 H. The results are given in the following table. They show the manner in which the effect in question increases with the strength of the field.

TABLE.

Influence of the strength of field upon the electromotive force of magnetization.

Strength of field.	E. M. F. in volts.
2,000 H.	.0008 volts.
3,600	.0045
5,040	.0208
7,770	.0386
8,400	.0424
12.750	.0487
16,300	.0510
19,700	.0680

We had noticed in the course of our experiments that a layer of the more or less magnetic solution of the salts of iron, produced by the reaction, always gathered around the induced poles of the electrode within the field. In this way a two-fluid battery was formed between the iron within the field and that outside, whenever the surface nearest the poles of the magnetized electrode was exposed. The terminal within the field was thus surrounded by a concentrated solution of its own salts, and was in a measure protected against the direct attack of the acid. In the case, however, in which a neutral portion of the electrode within the field was exposed, the products of the reaction were continually withdrawn by magnetic attraction towards the pole-pieces, and the surface was left more open to attack than the opposing electrode outside of the field.

For the purpose of ascertaining whether this arrangement of the solution in the field would tend to produce the effects which have been described, measurements were made of a variety of batteries in which iron formed one electrode. The results were such as to make it evident that the influence of the magnet could, in part at least, be thus explained. An iron-carbon cell, the liquid being nitric acid diluted with one part of water, was found to have an E. M. F. of .88 volts. When the acid was placed in a porous cup, containing the carbon pole, and the iron was submerged in weak sulphuric acid (1:10), the E. M. F. rose to 1.83 volts. The same metals in dilute sulphuric acid containing potassium bichromate gave 1.05 volts which was increased to 1.32 by placing the carbon and bichromate solution in a porous cup and the iron in dilute sulphuric acid. A cell with iron and platinum, in a solution consisting of 200^{cc} of strong hydrochloric acid, 200^{cc} of water and 20^{grms} of potassium chlorate, gave 1.17 volts. When converted into a two-fluid battery, the iron submerged in weak sulphuric acid, the platinum in the above solution, the E. M. F. became 1.39 volts. When the iron in the last case was submerged in dilute hydrochloric acid the result was nearly the same, the E. M. F. being 1.41 volts. In sulphuric acid containing potassium permanganate the same metals gave 1.44 volts, which rose to 1.60 volts when the platinum and solution were placed in a porous cup and the iron was dipped in sulphuric acid containing no oxidizing agent. Iron and platinum in ferrous chloride showed only .74 volts, but a two-fluid battery with iron—dilute hydrochloric acid—ferrous chloride—platinum gave 1.07.

In all these cells the electromotive force obtained by the solution of iron with ferric reaction was smaller than when a ferrous reaction occurred. The application of this fact in the explanation of the electromotive force of magnetization is very manifest. When the *poles* of an electrode within the magnetic field are exposed to action, the gathering of the salts of iron around the exposed surface tends to bring about a change from *ferric* to *ferrous* reaction and to *increase* the electromotive force. A corresponding *decrease* follows when a neutral surface is exposed within the field. The extent to which the electromotive force of a cell in which a ferric reaction is taking place may be reduced by briskly stirring the solution and exposing the surface

of the iron to the fresh acid, thus doing mechanically what is done magnetically when the reaction occurs, at a neutral surface, within the field, was shown by the following experiment. A one-fluid cell, consisting of iron and platinum in nitric acid diluted with four parts of water, had an electromotive force of 1.07 volts. Stirring reduced it to .95 volts. When left undisturbed it immediately regained its former intensity.

The electromotive force developed between the poles of one iron electrode placed within the magnetic field and the neutral parts of a similar electrode in the same cell, will also exist between the poles and intermediate portions of a single piece of iron. Consequently there will always be local action between different portions of the surface of iron exposed to chemical action within the field, the currents passing through the liquid from the regions nearest the induced poles.

It is doubtless to this local voltaic action, which has its source in the electromotive force of magnetization, that the various phenomena, described in our papers on *the chemical behavior of iron in the magnetic field*, and on *the destruction of the passivity of iron by magnetization*, are to be ascribed.

THE COMPARATIVE VALUE OF THE ALTERNATING TRANSFORMER AND CONTINUOUS CURRENT SYSTEMS FOR CENTRAL STATION LIGHTING.[1]

BY F. B. BADT.

We have heard three papers on apparently the same subject, though each of these papers was named differently by its author. I know a good many of you are under the impression that I will be an advocate of the alternating system, against the continuous current system; but such is not the case. In the title I have given my paper, I have narrowed this discussion to its proper limits. I do not believe, by any means, that the alternating transformer system will be substituted for isolated lighting, or for lighting within moderate distances, but I do believe that for an economical central station lighting system, the alternating transformer system is the best in existence. This remark may seem superfluous, but lighting within short distances, and even isolated lighting, has been dragged into the discussion on this subject. Although the author of the first paper read apparently tried to show that the only practical system for central station lighting of to-day, is the three-wire system of, say, not exceeding 230 volts, I propose to show to you that this attempt is not even consistent with the practice of the company this gentleman represents. In the first place, let me read an abstract of a circular concerning the Edison municipal system.

I quote: "The Edison municipal system has especially been devised to meet all the requirements of perfect outdoor illumination. * * * The current used in this system is of high tension (1,200 volts), which would be unsafe to introduce into dwellings, hotels, stores, or buildings of any character, where the wires and sockets are liable to be handled by inexperienced persons, but when they are stretched on poles in the open air, and the lamps are attended by persons who have been properly trained, all danger to the public ceases. If desired, the circuits for this system can be laid underground at a reasonable cost.

"Each lamp is screwed into a socket, which is protected from rain by a metal hood, and in the upper part of the hood is placed an apparatus that closes the circuit whenever a lamp carbon breaks, thus keeping the continuity of circuit uninterrupted. At the same time an instrument in the station indicates the breakage, so that the attendant may be sent out with another lamp to replace the broken one."

N. B. I hope he is provided with a bicycle.

Secondly, I will quote from a paper read by a gentleman during the Edison convention in Chicago, February, 1888:

"A modification of the Edison three-wire system was mentioned where two Edison 600-volt, 26 ampere dynamos, furnished current for several hundred lights; five 110-volt lamps being used in series on either side. The dynamos run without sparking, there is no more evidence of high pressure visible at this plant, or in the municipal 1,200-volt machines, than with 125-volt dynamos. There is probably no more perfect plant running than this, which has been in service since the middle of last year." And, again, "Within proper limits, the principle of high pressure is not absurd or inconsistent with correct principles of future progress. The idea underlying the transformer is the logical outcome of experience, but thus far we have no satisfactory application to general commercial uses, excepting, possibly through the electric motor."

Now, gentlemen, in both cases an electromotive force of 1,200 volts is employed, and they call the last-named system a "modification of the Edison three-wire system." If what we heard in the first paper is true, why does the same company employ an electromotive force up to 1,200 volts? The 1,200 volt three-wire system, as I understand it, is used for store lighting, and is introduced into houses; while in the pamphlet concerning the municipal system, the introduction of 1,200 volts into houses is condemned.

Where is logic? Where is consistency? I cannot see it, but I hope that during the discussion which probably will follow the reading of this paper, some of the gentlemen will be kind enough to explain it to me. I am well satisfied that there is a tendency, even among the most ardent advocates and admirers of the low tension system for central station plants, to occasionally raise the electromotive force when they cannot raise the necessary money to buy copper enough for their feeders and mains on the 230 volt three-wire plan. There is certainly less objection to even a 1,000 volt alternating transformer system than to the introduction of a 1,200 volt continuous current into houses.

Now, gentlemen, what I believe is that all these systems, namely: Multiple arc, three-wire and multiple series *continuous* current, as well as multiple arc, multiple series and transformer *alternating* system, are good in themselves, and that it is our task to find the proper places and the proper conditions for each. Each one has it place. We all agree that for isolated lighting, the multiple arc system is the best; whether continuous or alternating is a question which I do not want to answer here. For longer distances we will properly use according to circumstances, multiple series of two lamps (three-wire) or multiple series of more lamps, again either continuous or alternating. And for still longer distances, we will employ a general system of incandescent lighting, where all points, near and far, must be reached in order to supply *all* customers, the *alternating transformer* system. These few remarks will probably outline my ideas of the application of the different systems of incandescent lighting under different conditions. What I want to show, however to-night, is the comparative value of the alternating transformer system and the continuous three-wire system for central station lighting. I will adhere to the points named in the previous papers, namely:

First—First cost.
Second—Economy, efficiency and depreciation.
Third—Reliability.
Fourth—Variety and value of the possible sources of revenue.
Fifth—Safety to life.
Sixth—Effects upon existing property.

First and Secondly—First cost and economy. (Efficiency and depreciation.)

It was shown in the first paper that the cost of the conductors transmitting a given amount of energy at given loss for a given distance varies inversely as the square of the initial electromotive force employed. In the accompanying figure, circles 1 to 6, show the combined cross-section of copper feeders at five per cent. loss for 500 16 c. p. 110-volt lamps at a distance of one mile. They represent:

Circle 1—Multiple arc. (110 volts.)
Circle 2—Three-wire system, according to Professor Forbes (220 volts).
Circle 3—Three-wire system, according to H. Ward Leonard (220 volts).
Circle 4—Groups of five 110-volt lamps in series (550 volts).
Circle 5—Alternating transformer system (1,000 volts).
Circle 6—Alternating transformer system (2,000 volts).
The ratio is as follows:

TABLE No. 1.

Fig.	1	2	3	4	5	6
System.	Multiple Arc.	Three-wire. Forbes.	Three-wire. H. W. Leonard.	Multiple Series.	Alternating Transformer.	
E. M. F.	110	220	220	550	1,000	2,000
Ratio of cost of feeders.	328	246	108	13	4	1
Cost of feeders per lamp at 5 % loss at one mile	$71.00	$53.00	$23.00	$2.80	$0.85	$0.21

I think this table is perfectly clear without any further explanations. I will repeat, however, the statement made by Mr. Slattery, that according to Professor Forbes (as shown in his paper published in the New York ELECTRICAL ENGINEER, July, 1885), the saving of the three-wire over the multiple arc system is only 25 per cent., and that to assume any more saving may suit American financiers, but is not electrical engineering. The originator of the so-called Edison three-wire system, Dr. Hopkinson, of England, thoroughly coincided with Professor Forbes in this view.

For the sake of argument, however, I will assume whenever I speak of the three-wire system, the figures given by Mr. Leonard, or a saving of 66⅔ per cent. over the multiple arc system.

Table No. 1 also shows the cost of feeders per lamp, at five per cent. loss, at one mile, assuming the cost of copper at 20 cents per pound. In Mr. Leonard's paper the parallel was drawn only between the thousand volt alternating system employing 50-volt

1. Read before the Chicago Electric Club, at a special meeting, April 23, 1888. The fourth of a series of papers upon the subject, "The Continuous Current *vs.* the Alternating Current," before the club.

lamps and the three-wire system employing 110-volt lamps. I hardly think this fair, as it increases the cost of copper wires for the secondary circuits four times the cost of the copper wires in the branches of the three-wire system. In making this comparison the most economical alternating systems employed to-day in Europe and America should be considered. These systems employ an electromotive force in their primary mains of about 2,000 volts and use 110-volt lamps in their secondary circuits. Any improvement which in future should be made in these lamps, will, of course, be an improvement in the alternating transformer system as well as in the three-wire system.

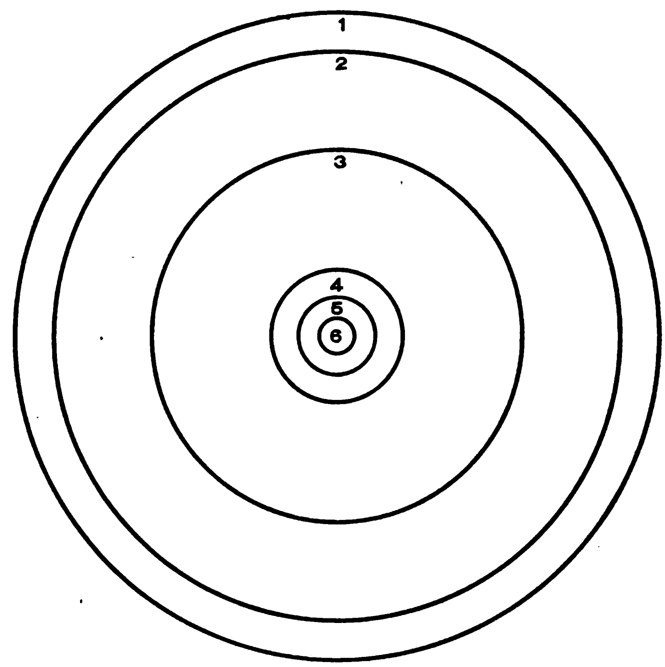
Now, in comparing the cost of the two systems, I will, for the sake of argument, again compare the three-wire system to the 1,000-volt alternating system. Let us assume that the cost of feeders per lamp at a certain distance for a 1,000-volt alternating system at 2½ per cent. the loss is one dollar. Then, according to Mr. Leonard, the cost of the copper for the three-wire system would be $27.50. Table No. 2 gives the cost of the two systems at 2½ per cent., at 5 per cent., at 10 per cent. and at 20 per cent. loss.

TABLE No. 2.

COMPARATIVE COST OF FEEDERS PER LAMP.

Loss in Feeders.	Three-wire System.	1,000 volts alternating System.	Difference of cost between the two Systems.
2½ %	$27.50	$1.00	$26.50
5 %	18.75	.50	18.25
10 %	6.87	.25	6.62
20 %	3.43	.12½	3.30

You can very easily see that the ratio in columns 2 and 3 is the same, but I want to draw your attention to column 4, showing the difference of cost per lamp in the two different systems under the conditions named. Suppose now that the cost of machinery, including boilers, pumps, engines, dynamos, house wiring and lamps in each case is about $15,000 for a 1,000 light plant. We would have to add in the three-wire system, figuring on 20 per cent. loss with full load:



$$1,000 \times \$3.43 = \$3,430.$$

In the alternating system we would have to add,

$$1,000 \times \$.12\tfrac{1}{2} = \$125.$$

But we will allow five times this amount in order to enable us to get a wire of very high insulation. This would make $625. In addition we should calculate $3,000 for transformers ($3 per lamp). This would make a total of $3,625.

It must be borne in mind, however, that a pole line, or underground conductors, for the three wire system would be much more expensive than for the alternating system, for obvious reasons. This would give us the following total result:

Total cost of 1,000 light three wire system, $18,430.

Total cost of 1,000 light transformer system, $18,625.

This would show the three-wire plant $195 cheaper than the alternating plant.

But now let us make some calculations on 2½ per cent. loss in the feeders; and we find that the feeders for the three-wire system would cost

$$1,000 \times \$27.50 = \$27,500,$$

and for the transformer plant:

$5,000 (again allowing five times the cost of copper for good insulation) and $3,000 for transformers, making,

Total cost of 1,000 light three-wire system, $42,500.

Total cost of 1,000 light transformer system, $23,000.

This would make the transformer system $19,500 cheaper than the three-wire system.

You can very easily see the trick in this calculation. Take a certain amount of money as cost for the entire plant, excluding copper feeders in both systems, and also excluding transformers in the alternating system; and assume a comparatively high loss in feeders; the difference in cost for such feeders in the two systems will then appear as a small percentage of the total cost of the plant. Then assume a high efficiency of such conductors, say, only 2½ per cent. loss, and the cost of such feeders will be a very large per centage of the total cost of the plant. You see in column 4 of table No. 2 that though the ratio at different losses is the same, the difference in cost will appear very small when a large loss in the feeders is allowed.

This method of calculation is not electrical engineering, but is instead a calculation invented, and probably patented, by some selling agent, who worked on commission. You can very easily see that if you want to sell a low voltage system, a high loss must be assumed, but if you want to sell a high tension transformer system, a small loss in feeders is permissible and competitive with the low voltage copper mine system. Thus you can make the total cost of the low voltage plant appear smaller or greater than the total cost of the alternating plant, as occasion may require. I very reluctantly make public this trick of the trade, but there is no charge for it to those gentlemen who should not have known it.

Now the question, of course, could be raised, why not figure on a higher percentage of loss in the feeders and still get the good results as shown in the first paper. I simply say this: Assuming a high loss in copper feeders is poor electrical engineering; it is a permanent waste of power; it requires complicated apparatus and permanent attention to keep the pressure alike in the different feeders with varying loads; it will cause greater lamp breakage, as necessarily even in the best laid out system, the potential will very often rise in some of the branches far above the normal; it necessarily must be quite a complicated task of electrical engineering to get all the conditions right for best results. On the other hand, with a small loss and a nearly constant pressure kept at the main distributing point, all these difficulties disappear. The electrical engineering part becomes very simple, and lamps can be attached almost anywhere to the line without throwing the system out of balance. Simply the impossibility of advocates of the low tension three-wire system inducing capitalists to spend money enough for such large conductors, as a small loss in the feeders would require, prohibits them from acknowledging all these advantages; and they necessarily must claim that it is good economy to lose more energy in the wires.

You can very easily see that the average load and loss question in table No. 1 of the first paper was simply introduced in order to make the loss appear smaller than it really is. Now I think I can save a good many arguments by simply giving you some information concerning the wires running out of the central station of a three-wire low tension plant in Minnesota. The first pole near the station carries all the outgoing wires; there are 54, varying in size from No. 0000 wire to No. 6. About one-half of the wires are No. 0000, and the remainder vary from 0 to 6. Lamps of various candle-power are put up, whose equivalent amounts to about 7,500 10-c. p. lamps. The average number of lamps burning during the day amounts to 2,000, while the average number in use during lighting hours is about 7,200. The loss in these feeders amounts, with full load, to about 20 per cent.; in one circuit it is even more. The claims, as far as economy is concerned, are 10 10-c. p. lamps per horse-power, including the loss in the conductors. The station is equipped with 10 dynamos, five engines and boilers for about 1,000 h. p. There are 14 employés connected with the station. The coal consumption for 24 hours, is about 53,000 pounds.

Now Gentlemen, taking these data, do you think that the theoretical tables and curves we had explained in the first paper were known to the gentlemen who laid out this station? The fact of the matter is that such a station can neither be economical nor on a paying basis. It can be only the laughing stock of electrical engineers except those who own some stock in the concern.

A 2,000-volt alternating system would, of course, show up far better than a 1,000-volt system, as far as first cost and economy is concerned. Even granting that the efficiency of an alternating dynamo is not quite as good as that of the continuous current dynamo, and that a small percentage of loss will occur in the transformers, what are these in comparison with the enormous loss in the feeders of a three-wire system, and the necessity of all

the complicating balancing devices at the station necessary in that system?

There is one point, however, which has not been touched upon, and that is that the whole calculation made in the first paper, was based upon the fact that the number of lamps fed by different feeders was at all times reduced in the same proportion. I know from practical experience that in most plants, this is hardly ever the case, and that resistance must be introduced to equalize the varying losses in the different feeders. This not only means waste of power continuously, but it also means wages of employés to watch the necessary instruments continuously, and to keep the different feeders balanced. So much for economy and efficiency. Of course, I do not want to repeat all the points covered in the paper read by Mr. Slattery nor by the latest communications to the electrical journals made by advocates of the alternating system against the three-wire system as expounded by Mr. Leonard.

As far as depreciation is concerned, let me again draw your attention to the Minnesota three-wire station and let me simply ask the question, would you rather repair transformers, or would you prefer to keep a pole line covered with a network of naked wires in repair? Suppose customers did not renew their contracts for lighting; which would be cheaper, to take a transformer and place it somewhere else, or have a high priced electrical engineer sit down and calculate how to balance that line again and take a couple of hundred lights from one place and transfer them to another point on the circuit. These points I think naturally apply to the chapter headed "depreciation."

I grant that well insulated wire will depreciate more rapidly than bare copper wire; but for my part I would prefer to keep six well insulated wires in repair, than a pole line with 54 naked wires as here illustrated.

Whether the depreciation of a high tension dynamo, is greater than that of a low tension dynamo, is a question that can only be answered after more experience than we have had up to this time.

Thirdly—Reliability.—I can see scarcely anything in the corresponding chapter of the first paper which still needs answering. I certainly can not see that for the reasons given, a continuous current system is any more reliable than a transformer system. Again let me draw your attention to the picture. I think that in the network of wires represented, troubles are more likely to occur than in six well insulated wires. Practical experience so far has not shown that the alternating transformer system is not as reliable in operation as the low tension continuous current system.

That a switch-board in an alternating central station plant should be more expensive than a switch-board and the necessary apparatus to run a three-wire plant, is something very surprising to me. I think that from what I have seen of the two systems, that the traps used in a three-wire station plant cost at least five times as much as those used in an alternating plant. What our contemporaries in Europe think of the reliability of the two systems, will best be illustrated by the following examples:

First—Milan, Italy, had a low tension direct current 10,000 light station. To reach a theatre 6,500 feet off, they added a Zipernowski-Deri 1,800-volt alternating transformer system, using underground cables.

Second—Dijon, France. This town had a low tension direct current central station, located in the centre of the town. The city council regarded the noise of steam engines, smoke, etc., in the heart of the city, a public nuisance, and compelled the local company to go to the outskirts. The company abandoned the whole continuous system and replaced it by a Zipernowski-Deri 1,800-volt alternating transformer system.

Third—Rome, Italy. A large central station is being erected and is partly finished—all done on the Zipernowski-Deri 1,800-volt alternating transformer plan, with a capacity of about 18,000 lights at distances of 10,000 to 16,000 feet.

Where, gentlemen, is the low tension plant reaching customers at such distances? I could go on in this way *ad infinitum*, but I think these few examples will suffice.

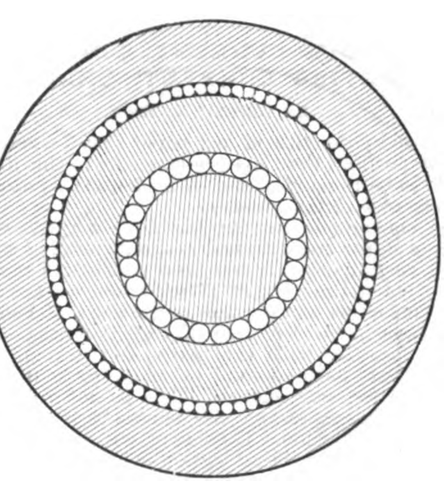
Fourthly—Variety and value of the possible sources of revenue.—The question of increasing the income from the central station by renting out power has been ventilated before, and it has been shown that it is not by any means impossible to run motors on the alternating transformer system. It has been found furthermore that in practice it is advisable to run a separate circuit for the distribution of power. There is no objection to using continuous current dynamos for this purpose. It could be said that extra dynamo capacity would be necessary in such cases, but I hardly think this is true. It certainly can not be expected that the same dynamo will run day and night in succession without ever stopping. I think that a certain reserve is necessary in any event. In the central stations I have seen only a part of the dynamo capacity is used during the day and the whole during the main lighting hours in the evening, leaving no reserve whatever. If these same dynamos should be loaded, running motors all day, there would be, in my opinion, a continuous strain put on the apparatus, which is certainly not advisable.

I quote from the first paper the following: "Then there is an almost unlimited number of applications of a continuous current on a small scale for such purposes as fire alarms, burglar alarms, distribution of time, annunciators, tickers, electro-plating, telegraph lines and telephones, all of which rely upon a continuous current."

Now I would like to have somebody tell me from what central stations such applications have been made on a large scale and on a paying basis. I do not know of any, and I think no central station would like to be troubled with these infernal little nuisances. The amount of money which could be gotten as revenue for furnishing current to these appliances would certainly not compensate for the trouble they would continually cause. Therefore I must say that I cannot see that the alternating system is any more dependent for its revenue upon the sale of light alone than a continuous current system.

Fifthly—Safety to Life.—The danger to human life from high tension alternating currents is always held up as a bugbear by the advocates of the low tension continuous system. In the first paper it was stated that it has been conclusively proven in practice that a 1,000-volt alternating current is fatal to human life and will kill a horse. I do not know of any experiments made in that direction, but it would certainly be interesting to know how much larger an animal than a horse could be killed by a 2,000-volt alternating current. A telephone operator at Pittsburgh, who was killed dead (by the first paper) with a high tension current, while handling the switch-board at the telephone exchange, has come to life again, in a communication to the *Western Electrician*. Maybe the same will happen yet with the horse. The fact of the matter is that at least 90 cases out of 100 where persons have been killed by the high tension current, death has been caused by the extra current set up in the field of a series dynamo when the external circuit was broken by the victim. Now, gentlemen, this danger does not exist in any alternating system.

The field of the alternating dynamo is separately excited, and such a powerful extra current cannot be set up and discharged



through the body of the careless workman even in case he should break the external circuit. I therefore claim that the main cause for *fatal* accident does not exist in the alternating high tension system. There is another danger which I think is greater in the continuous current system than in the alternating high tension system. Just look at that picture hanging before you again, and imagine a workman in that network of wires short-circuiting two of those heavy copper conductors by some means. The result would be a pound or so of molten and fused metal which would not only inflict very severe wounds but might even prove fatal. Quite a number of cases have come to my knowledge where persons have lost their eyesight or got otherwise mutilated by such accidents. You must remember that the wires of a low tension system are mostly bare while the wires of the high tension alternating system are well insulated. It may be asked why, in the case mentioned, the safety strips would not prevent such an accident. I will say that heavy fusible plugs melt rather slowly and would not break the circuit in time to prevent the accident. The smaller safety strips of the high tension alternating system carrying only a few amperes would respond a good deal quicker, though, as mentioned before, such an accident is less liable to happen in this system.

Sixthly—Effect upon existing property.—Why a low tension continuous system should be better protected by safety strips than a high tension alternating system is a conundrum to me, and I refer to the discussion of this matter following the reading of Mr. Warner's paper. The inductive influence which might cause trouble to telegraph and telephone lines can be just as easily avoided in a transformer as in a low tension direct current system. For underground work, I think a cable, as represented in the accompanying figure, would prevent all such troubles and would

furthermore prevent the retardation of the alternating system, as explained in a brief article of mine published in the *Electrical Review*, September 3, 1887. It may be mentioned here that wires carrying an alternating current are not in danger, from electrolysis, and that the wires keep cleaner if fastened underneath ceilings or on walls. Wires carrying continuous currents will very soon show a layer of dust and dirt which will appear as a demonstration of the magnetic whirls surrounding the wires.

In conclusion, I will give a *resumé* of the advantages of the alternating transformer system, as used for station lighting, in comparison with the three-wire system of distribution.

ADVANTAGES.

1. Location of central station plant need not be in the expensive centre of the city, but cheap real estate and power miles off can be utilized, thus decreasing the cost materially.
2. All customers near and far may be reached on a paying basis.
3. The price of conductors for feeders and mains is reduced to a minimum.
4. These wires being very small, the cost for poles and erecting lines or of underground work is materially reduced.
5. It does not take any great electrical engineering skill or complicated calculations to lay out such a system and make any alterations which may be necessary in the course of time.
6. The system is very simple, requires comparatively few stationary appliances and fewer employés for regular running and repairs.
7. The small loss in the feeders will result in greater efficiency, more lamps to the horse-power, smaller engines will be employed, less fuel consumed, and the earning capacity of the whole plant will be greatly increased.
8. It is easier to keep the electrical pressure constant thus burning the lamps at all times at even candle power and lengthening their average life.

THE CONTINUOUS CURRENT, LIMITED, vs. THE ALTERNATING CURRENT, UNLIMITED.[1]

BY GEORGE CUTTER.

YOU will see by the title of my paper that I assume rather a more positive position than my predecessors in this discussion. I do not claim to be impartial, and then produce arguments wholly tending to one side of the question.

That the continuous current has done a great work in the distribution of lights from central stations, none of us will deny, and, that in certain cases it has been successful in spite of the limitations of such a method of distribution, we are also pleased to admit. The effort among the originators of central station systems has been in the direction of high potential. We are all more or less familiar with the many and various devices and methods that have been adopted to enable us to use high potentials in distributing our energy. This is not only the case in electrical work, but it is also the tendency in other classes of central station distribution. Outside of our own especial department, one of the most striking instances is the high pressure hot water system of distributing heat in Boston. The statement of the chief engineer of this enterprise seems to me quite appropriate to our work, in that he considers "the distribution of heat a transportation problem." We can also consider the question of distributing electricity a "transportation problem," and the question is, the cheapest method of transporting the energy we sell. The cost of installation for doing this should, of course, be as light as possible in proportion to the work accomplished.

In the discussion which followed the reading of the last paper before the club, I maintained a position somewhat different from the other participants in the discussion, and immediately decided upon the title of the paper that I rashly offered to prepare, viz: "Continuous Current, Limited, *vs.* The Alternating Current, Unlimited," because I wished to emphasize the arguments offered at that time. I do not wish to close the door on the continuous current, nor on any department of electrical work whatsoever, as I wish for the greatest work possible with electricity, and stand ready to rejoice at the success of any method, be it with continuous current or without. I think such a position should be made very prominent as it contrasts so forcibly with the spirit of the first paper. I wish merely to show that in the present stage of our industry, the alternating current has decidedly the best outlook.

Shortly after the reading of the first paper I prepared a picture of the pole line in front of a station of an Edison three-wire system in New England, with which I was quite familiar, and then also planned the necessary pole line for the same number of lights on the converter system. In the discussion which followed the reading of Mr. Slattery's paper, I mentioned this point, of the relative appearance of the wire work of the two systems, to show that the relative depreciation was not simply that between pure copper and transformers.

As Professor Badt produced a very pretty picture of the three-wire system in Minnesota, I simply reproduce the same picture, with exception of the poles and wires. (We omit the pictures referred to here, as too large for our space. They are given in the *Western Electrician*, April 28 and May 12.) Here I have represented the necessary wires for 7,500, 10 c. p. lamps on the converter system. Not knowing the distance to the lamps that produced such a net-work of wires as was pictured in Professor Badt's illustration, I adopted the greatest distance which Mr. Leonard knew of an Edison feeder, viz.: 6,000 feet. I then calculated on the basis of one-half the number of lamps at 3,000 feet, and one-half 6,000 feet away, which you will readily perceive would be an exceptionally difficult condition for the continuous current to fulfill. For this work I have 10 wires in place of the 54 as pictured for the three-wire system, and in place of a good many more than 54, as would be necessary if the lamps were distributed as I have figured, and the wiring was done on the three-wire system. Moreover, my figures are for 2½ per cent. drop, whereas the three-wire system is on a drop of 20 per cent., giving a good margin for any difference in efficiency in the apparatus. Mr. Bliss made the remark "that the plan selected by Professor Badt was an exceptionally severe one for the three-wire system, inasmuch as all the wires went out in the same direction." I look upon it as a fair representation of the wiring for this number of lamps on the three-wire system, with the exception of having so many of them on the same poles. The difference would simply be, having more poles and more routes.

By leaving out some of the factors of the installation, it is easy to maintain by figures most any position we wish. This is the method adopted by some business men, and it is also the method in the first paper. No account whatsoever, was taken of the construction of the plant, or of the cost of poles, etc., which make up part of the installation, and which all tend to increase the cost of the three-wire system much more rapidly than that of the alternating converter system.

Mr. Leonard figures the cost of copper for the feeders of the three-wire system, and the copper and the converters in the converter system, and draws a very pretty diagram to show how far he can go with a continuous current three-wire system for the same money as with the converter system. The very best answer, to my mind, to these figures, is to have Mr. Leonard's customers ask him to put in the installation at the prices he gives. We will, in such a case, give him the advantage of the difference in price of copper.

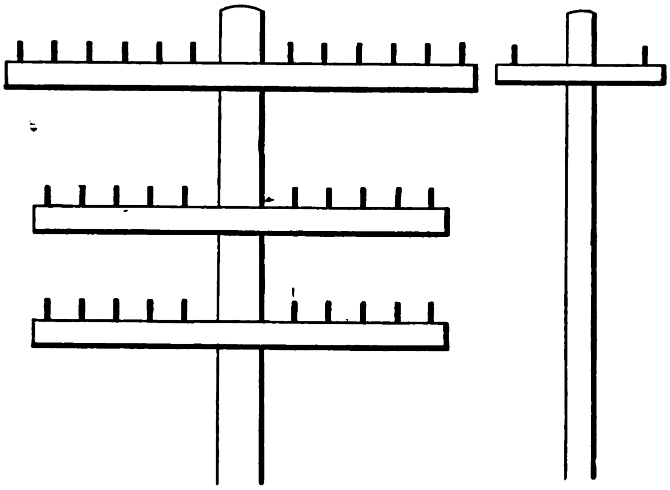
One feature of this figuring is something I do not quite understand; for instance, in table No. 3 of H. Ward Leonard's paper, it is stated, "that with 30 volts maximum loss, the cost of copper per lamp for the three-wire system at 6,000 feet, would be $3.87. Then, in his analysis of this table, he calls this 6,000 feet "the average feeder length," and says this is equal to a circular area of 18,000 feet, or 3½ miles. How many times I have wished that the cost of copper for distributing our lamps was as elastic as this implies. Now, a radius of 18,000 feet circle is 9,000 feet. Mr. Leonard figures 800 feet between feeder terminals for his mains, and 100 feet from the mains to the lamps. We will suppose that half this distance between feeder terminals, 400 feet, and the 100 feet for the service wires, are in a direct line with the feeder itself, thus making the feeder 6,500 feet. I would like to understand how the cost of wires for a lamp 6,500 feet away can be the same with the same system as for 9,000 feet away. The relative cost of the wire under such circumstances being as the squares of the distances, I make it out that the wire work for 9,000 feet costs about double that for 6,500 feet.

The continuous current advocates, try to scare away the alternating current with the cry of "danger." To attempt this at the present day, in face of the large amount of good work that has been done with high tension currents is about like trying to mop out the ocean with a kitchen mop. The people who raise the cry, with few exceptions, do it for a check on the alternating current, not because they fear the danger they portray. If the danger is such as to preclude the high tension system, we might as well stop at that point and not bother to figure on the cost, depreciation, etc., of high tension plants. Their remarks, and the practices of the companies some of them represent, show that neither of them fear this danger. They are kind enough to say they think the converter system might be used as an adjunct to the continuous current plant to reach outlying districts beyond the limits of their favorite, but limited system. If the alternating current is such a dangerous fellow, as they try to prove, why should they advocate its use for outlying points, especially, when such points would consist largely of residences? I must ask them if they would distribute lamps around the family hearth for servants and children to handle, with a system that is too dangerous to use in stores and offices? The converter was developed on purpose to enable us to reach customers at a distance, and still have the E. M. F. at the lamps reduced to a harmless quantity. By systems of installations already in use, the secondaries can all be made absolutely safe. The danger then is reduced to the primary wires.

1. Read before the Chicago Electric Club, May 7, 1888. The fifth of a series of papers upon the subject, "The Continuous Current *vs.* The Alternating Current," before the club.

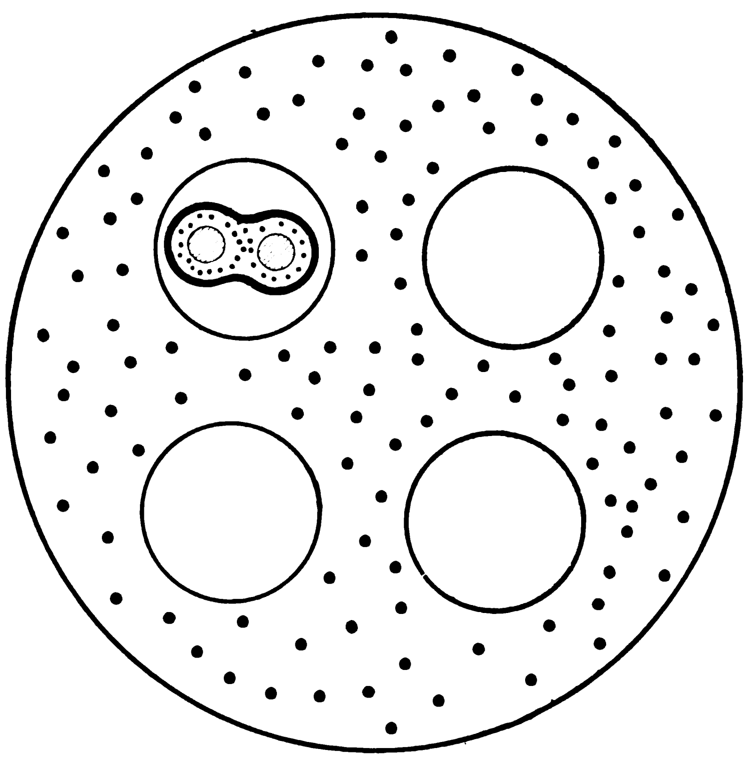
Dynamos of 1,200 volts are run on three-wire systems. I must therefore ask a direct question. Is a 2,400 volt system of distribution continuous current, less dangerous than 1,000 volts alternating? If the tension of 1,000 volts is dangerous why install and advocate systems of 2,400 volts?

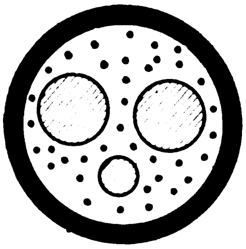
I feel that I must raise another point to show that fear of high tension is assumed for business policy, and not philanthropy. Suppose we do not adopt the policy of grounding the secondary,



and some transformer leaks. The individual secondary is thereby subjected to the same tension to ground as the primary, provided, of course, that the other ground comes on the opposite primary wire. On this secondary circuit may be but few lamps that people could handle. This is probable. Therefore the danger of such a leak only exists in a few lamps.

Mr. Leonard says, the best method of distributing the electric energy from a distant point is with the motor generator. Two





1,200 volt dynamos to be connected in series and the circuit carried to the upper story of some building where the motor generators are placed. From this upper story the regular three-wire low tension system is distributed. Leave out the item of cost of the secondary system, and its limitations, but consider now the danger. If any one motor generator of the whole lot should leak, there would then be the danger of the 2,400 volt tension throughout the whole network. I quote Mr. Leonard, "The motor generator for this work is ready for the market, but it has been learned the cost per lamp can be very materially reduced by increasing the speed."

The alternate current converter is, as Mr. Kennedy well said, "The simplest piece of apparatus imaginable," and it has no moving parts whatever, no increase of speed; therefore the relative danger of leakage between the two converters is almost as one to infinity, in favor of the alternator. And still the leak in the alternate converter endangers a few lamps only, whereas the leak in the motor generator endangers the whole network. Here is a company with able representatives facing their almighty dollar, and advocating a system in which a leak would give 2,400 volts throughout a network of wires, and then facing somebody else's dollar and crying "danger" against a system in which a leak gives 1,000 volts to a few lamps, and even that danger can be eliminated.

When Faraday was showing some experiments illustrating his great discoveries, and showed how simple it was to produce the electric spark with his apparatus, the dean said, "He was sorry for it, as it put new power into the hands of the incendiary."

Gentlemen, when any new devices are put forth to the world, there are always people who cry them down for one reason or another and generally the cry of danger is raised, but our progress is not to be checked in any such manner. These considerations lead me to believe that our continuous current friends do not fear the danger, or consider it should hinder our progress beyond the limited field of the continuous current. And, as I believe the danger of distributing electric energy by high tension alternating converter currents to be much less than the danger with gas, locomotives, steamboats, crowded streets, with all sorts of teams, and drivers, in fact, most of the methods and practices in crowded centres, I think we can proceed with the consideration of cost, depreciation, and revenue, to learn if the scheme is strong commercially.

I have also made another sketch, illustrating in a certain extent, the difference in the pole line between the three-wire system and the converter system; the large pole representing the pole in front of the Edison three-wire plant in New England, which was figured for 1,000 13 c. p. lamps, the longest feeder in the system being 2,400 feet. My friend, who has charge of this installation, writes me that he is now using 980 16 c. p. lamps, and therefore has not sufficient potential at the lamps.

The company have decided to reconstruct the whole wire work this summer. There are about 10,000 lbs. of copper in the feeders and mains, and a nice little half ton more in the connections in the station. If the company were fortunate enough to buy this copper at the price quoted by Mr. Leonard they would have to pay about $1,600, provided they used bare wire, but in this instance they used underwriters' wire, which, of course, costs 25 or 30 per cent. more, owing to the extra weight.

Every installation of this sort requires a system of feeder regulators, which are a very expensive factor in the first cost. In this particular case these regulators cost about $1,200, which is 75 per cent. of the cost of copper for feeders and mains. Any comparison in the first cost between the two systems under consideration should include all these different items.

I also have pictured the necessary pole and wires for 1,000

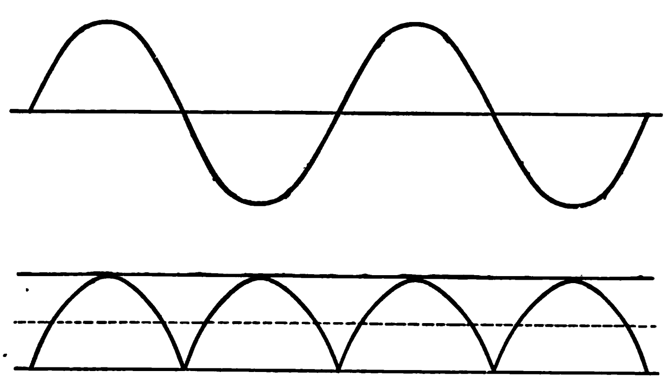
16 c. p. lamps, supposing they were all at a distance of 2,400 feet, which is much more severe than the three-wire installation pictured on the pole by the side of this one, and still you can all compare the difference. The alternating system requires no pressure wires because of the facility of making a voltmeter, which compensates for the variation in loads. As the alternator plant is operated with a very low percentage of drop, in this case I have figured on 2½ per cent The difficulties of regulating for change of load are very slight, and the apparatus for accomplishing this, very cheap. Moreover, wherever regulators are used for alternating currents, they consume little or no power in doing their work,—just the reverse of the continuous current regulators.

As a probable improvement in the incandescent lamp was mentioned, I would like to emphasize the fact that most makers of these lamps to-day are willing to guarantee about 25 per cent. better efficiency with the 50 volt lamp than with the 110 volt lamp, and the result of our experience in this direction thus far indicates quite decidedly that whatever improvement is made in the 110 or higher voltage lamp, will also give a proportional benefit in the 50 volt lamp. Briefly, then, the 50 volt lamp will probably always be 25 per cent. better than the 110 volt lamp. The importance of this difference in lamp efficiency is readily appreciated by all electrical engineers and by business men also, when they are able to sell 25 per cent. more energy with the same outlay for the plant.

The relation between dynamos and converters has been alluded to. This relation is only electrical, and not mechanical. Mechanical difficulties in a dynamo change the electrical relations very materially. How we wish that the mechanical conditions would allow us to run our armatures within about one-hundredth of an inch of our pole pieces.

As I expressed myself quite emphatically in relation to the relative reliability of the alternating and continuous current installations, I will not venture upon this point, the situation simply being that with equal engineering ability, the converter system can be made as reliable, yes, more reliable than the three-wire system, because of the greater flexibility in the converter system.

As to the relative depreciation in the two installations, I would like to call attention again to the two pictures of the station in Minnesota, and ask any practical man which he would prefer to



maintain for twenty years,—pole lines with a network of 50 wires, as shown for a three wire system, or a pole line with 14 wires for the converter system and the converters. Is this depreciation that between pure copper and the converters? And when we get to placing our circuits underground the relative depreciation will be decidedly in favor of the alternating system.

Mr. Lieb, the engineer in charge of the Milan station, has had considerable experience with the Edison tubes and Siemens cables, and also cables for 2,000 volt alternating system, and in a communication to an English periodical, he says:

"How closely allied the question of underground conductors is with the future of electric lighting from central stations needs no demonstration. The local engineers do not claim that this difficult problem has been completely solved in Milan; but what has been done in that direction thus far, makes it appear probable that no very serious difficulty will be met with in a general system of distribution of high tension currents by means of underground cables."

I have also made a picture of the underground conductors. full size, for 1,000 lamps on the three-wire system 6,000 feet away at 10 per cent. drop, and the same number of lamps on the converter system at 2½ per cent drop. If anything goes wrong with the large conductors and tubes, the street must be taken up for the repairs, whereas in the converter plant, the cables are drawn into conduits, as shown, which is the only proper method for underground distributions, and these wires can be withdrawn and new ones put in their places at comparatively small expense.

Just glance at that large plan and imagine the conditions under the surface of the street with all those tubes laying there like a gridiron barrier to any other work. The case shown is a mild one as compared with some places, where twenty odd tubes lay along a snug little strip twenty feet across.

The retardation caused by the iron in the neighborhood of the converter plant is of too slight a quantity to be considered at all in practice.

Early in my experience in making estimates for alternating plants, I wished to know whether I should make any allowance whatever for this retardation, and therefore, wrote to our people at Lynn for advice, as I knew they had experimented a great deal on this particular point. Their answer was, that I need make no allowance whatever, that in the installations they had made, they had never realized any loss from this cause. The figures certainly back up this assertion. A 40 light converter uses about 3⅓ h. p.

As Mr. Leonard quotes Bro. Kennedy as good authority on transformer work, I will quote him also, as he said distinctly that he "could use transformers with a loss of less than 2 per cent." My experience leads me to believe that this is correct, but I will take a loss of 5 per cent. mentioned by Mr. Leonard, which will give us a loss in a 40 light transformer of .16 h. p. running at full load. If empty, the loss would be much less than this. The primary wires for this converter have two amperes, passing at full loads through many convolutions placed very near the iron. As the loss in this transformer is electrical as well as magnetic (and probably largely electrical) the loss by retardation will be a small part of .16 h. p.

It is difficult to imagine a primary circuit of a 1,000-light converter plant to be so situated in relation to the iron in the neighborhood, as to use up the same energy by retardation as is used in a 40-light converter when empty, which shows pretty conclusively that the retardation from this cause is too small a factor to talk about.

This diagram is intended to represent the relative energy of the continuous and alternating currents. Drawing all the waves above our zero line then draw a line along the top of the waves for the 50 volt line. The areas of all the waves show the energy of the alternating current and the areas between the two straight lines that of the continuous current, provided the alternating current has the same voltage as the continuous current. In that case the actual energy is much less than the continuous current. As the carbon cools very slowly and the waves are very rapid, probably this is very near the actual condition.

The heat of a 16 c. p. lamp 52 volts may average less on alternating currents than on continuous currents, and still the illuminating power be practically the same to the eye because the impression left on the vision would be that of the greatest brilliancy with the rapid changes of the alternating current. This indicates that the actual energy in a 16 c. p. lamp is less on the alternating current than on the continuous current.

I have touched upon the various points of first cost, economy, reliability, safety to life, etc., in rather a mixed up fashion, and now I come to the most interesting part, and the most important part of the whole question, that is, "Variety and value of the possible sources of revenue."

In distributing our energy we wish that system which will enable us to accomplish the most, and which will be readily adaptable to the various demands. Some business men may adopt a system that can only be used in a limited area, and that at an enormous expense. It is barely possible that Mr. Bliss touched the keynote of this tendency on the part of some business men. We are all aware of the past relations of Mr. Bliss to the Edison company, and probably, therefore, he is more or less conversant with the business policy of this company. In the discussion at our last meeting, Mr. Bliss said, "The capital that is being furnished for those stations (referring to the large Edison stations in Chicago and New York) comes very largely from the same persons who made the first installation of a large incandescent plant that was put into the United States." Possibly, these capitalists have some other benefits from their investments than that arising from the actual income of the stations themselves. That has often struck me as a peculiar feature in the business of the Edison company, which company is mentioned because of the large amount of work it has done with continuous currents, and because they are about the only large concern that tried to close the door against the alternating current, viz: the capitalists who furnish the necessary funds for the largest Edison plants in different parts of the world, are interested in the sale of similar installations elsewhere; possibly they look to these sales for the reward of profit on these large central plants that have been put in at such an enormous expense.

As Mr. Bliss has promised a paper on the continuous side of this question, I certainly hope he will give us figures that will enable us to understand how the dividends can be paid by the actual earning capacity of large central stations of the continuous system, not only because I wish to know positively that these enterprises are a sure success, but also, for the benefit that such demonstrations will be to the alternating side of the question, because if that will pay which is so limited in its capabilities, we can certainly feel sure that another installation furnishing the same class of energy can pay still better by virtue of its greater flexibility and almost limitless possibilities.

In the discussion which followed the reading of Mr. Leonard's paper, this gentleman stated that the "cost of operating and maintenance of any system is certainly reduced if they can operate from one source of supply." Thus showing that he does not believe in various stations for supplying energy to a large city. The remark was made as applying to central stations, but it appears to me to apply also to accumulator stations, because they must be operated on low potential, therefore, there must be many of these accumulator stations, each one of which is of necessity equipped with many and varied devices for regulating the feeders, etc. That attempts are being made to run lights from accumulator stations, we are all well aware, and hope, of course, that they will prove a success, but that remains yet to be proven. When they are perfectly developed, and supplied with all the regulating devices above mentioned which appear to be necessary, the possibilities of profit may disappear, and I am free to admit I am afraid they will.

The idea of converting our energy seems to be the prevailing idea of to-day, and our electrical journals are filled with illustrations, paragraphs, figures, etc., about some sort of a converter system, alternating converter, continuous current converter, accumulator converter, each one trying to prove that his especial system of conversion is the best. This is interesting, as it shows pretty conclusively the general feeling that the continuous current of itself, is altogether too limited in its possibilities for the work that we have in hand all over the world to-day. Our industry is growing, and people are not satisfied with working within just such prescribed limits. Hence, the various devices that enable us to go beyond these limits,—and the alternating current seems to be just the thing wanted for the purpose, as it does its work in a manner not accomplished by any other converter system.

Admitting that the continuous current converter may be made quite a success, it still can never be placed about town in all sorts of situations, and of all sizes, as can the alternating current converter. It is a machine more or less difficult to keep in order, being, as Mr. Leonard says, "run at a high speed," that necessarily means constant watching. Therefore, these converters must be used in secondary stations with low tension system distributed from them. This is also the case with the accumulator. It also requires a great deal of attention, and if used for central station distribution, must be placed about town in secondary stations. As the network from each secondary station is low tension, we must still work on high percentage of loss, in order not to have too many stations, and this combination of low potential and high percentage of loss, means constant attention to the regulating devices, that is to say, every one of these secondary stations embraces more or less the difficulties of the present continuous current station. And, further still, the secondary network can give but a uniform electrical condition *theoretically*, therefore your continuous current, whether it is of the 3-wire system, multiple series system, continuous current converter system, or accumulator system, is limited, and very much so, in its possibilities. Any use of them at all, requires high engineering ability, and the very best of engineering ability can only accomplish a limited amount of work.

The alternating current is entirely a different sort of fellow; extremely flexible and unlimited. It enables us to start small and grow with the demands with but very little trouble in the calculations. The cost of the conductors being a very small part of the whole installation, it is easily determined what the installation will cost. Those of you who have made calculations for the continuous current plant, or have been called upon to furnish the necessary data for such a calculation, appreciate readily the difficulties involved, nearly all of which difficulties disappear the minute you commence to work with the alternating current. The change in the load of a considerable amount in one part or the other, it is readily taken care of by an ordinary man and at no very great expense. Possibly, a little work for the expressman to carry a few converter boxes from one customer who has given up lights to another who has taken some on. There is no great bother about maintaining proper potential. This current will also furnish almost any phases of electricity desired. Instead of having a couple of wires in our rooms which will furnish 110 volts and no more or no less, we have a couple of wires which will furnish any voltage, or most any quantity desired, so that if a new industry should arise where 8,000 or 10,000 volts are required, two little wires carrying the alternating current, will furnish the energy which can be converted to this potential. Or, if a very large quantity is desired of low potential, these same two wires will furnish it.

For the rental of lights alone the general impression has been, that the alternating current can do it satisfactorily.

The work of motors on the alternating current has been discussed sufficiently before the club, therefore we will await further developments in this direction. The alternate current motor is certainly further advanced to-day than was the continuous current motor when the work commenced with the continuous current distribution, so we will soon be able to rent power from our alternating network, provided it is found a matter of policy to do so from the electric lighting circuits.

There are other industries now before the world which certainly bid fair to become of great importance, and as one department has been pretty well developed, I will allude to that more particularly, and that is, the welding and manipulating of metals by electricity. I have been fortunate enough to secure a number of samples of metals welded in this way, showing that I am not dealing in "futures" when talking of this industry. There may be a large source of revenue to central stations that are providing alternating currents, in furnishing the energy for this class of work. As it may be said that the continuous current is also being used for the welding of metals, I must say that this method has not proven a success, having seen the operation in a large workshop in Paris, where they tried to make oil tanks by welding metals together with a voltaic arc; I know that the method is not at all a practical success as yet, as the metal is oxidized and destroyed, burnt up, so to speak, by the intense heat.

The continuous current can be used for electric welding, but as enormous quantities of current are required, the dynamo supplying the same must be near the work. This limits the continuous current very much for this class of work. Not so with the alternating current converter. We can attach to our two little wires a very small converter for jewelry work, or a very large converter for heavy welding.

Another feature of the question is this, it is easier to work the registering meter on the alternating current than on the continuous current. The difficulty in this class of meter lies in the fact that they must record in proportion to the number of lamps burning, or the amperes used, whereas the work done is, by itself, in proportion to the square of the amperes. This difficulty is quite easily met in the alternating current, by the use of a simple kicking coil, but it is not one easily met in the continuous current.

I have made a diagram (we omit the figure), illustrating the subject of my paper as a final summary of what I have tried to express. I think it shows pretty conclusively what my title implies, namely, the continuous current, limited, *vs.* the alternating current, unlimited. On the left I have pictured two large wires for carrying 1,000 amperes and 125 volts, which you will see equals 125,000 watts. Connected to these wires I have represented an accumulator, motor and an incandescent lamp. I do not mention time circuits, telephone or telegraph, as I do not consider them worth bothering with in an electric light station. These different factors are all necessarily 125 volts, not more or not less, simply limited to that phase. On the right of the drawing I have represented two small wires for 1,000 volts and 125 amperes, which is equal in energy, namely, 125,000 watts. The wires for this current are one-quarter the diameter of the others. I have represented, as connected to this circuit, one transformer, operating 52 volt lamps, one operating 110 volt lamps, one giving 20,000 volts, another giving 20,000 amperes for heavy welding, one giving 500 amperes for jewelry welding, and I have also Professor Thomson's method of charging the accumulators on alternating currents, and I have a motor. Here you see are two circuits side by side conveying the same energy, one of which gives us fixed E. M. F., and the other gives us almost any E. M. F. or quantity we wish. To carry the continuous current of such a quantity, 1,000 feet with a loss of ten per cent., we would need copper rods two inches in diameter, whereas, the other current can be carried at greater distances on a very small wire.

THE CONTINUOUS CURRENT vs. THE ALTERNATING CURRENT.[1]

BY GEORGE H. BLISS.

I MAY as well admit myself at the outset to be ignorant from personal experience in regard to the alternating current as applied to electric lighting, and confess to never having seen such a plant or station in operation. My early impressions of the alternating system from personal and published statements were very favorable, and I was highly gratified that a practicable method had probably been discovered for the economical distribution of electrical energy over greatly extended areas. There was something quite pleasant in contemplating this development. This country had given to the world a practical method of electric incandescent lighting, and it seemed only fair reciprocity for Europe to return the compliment by an alternating system which should greatly enlarge the sphere of the electric light industry. In looking forward to this discussion, which was to be largely educational to me, I anticipated that the friends of the able imitators of the alternating system who have made such substantial progress with its introduction in this country, would bring forward conclusive arguments for its general adoption. I have been disappointed in this respect, and there is a growing conviction in my mind that the compressed air, which made the monied foundation for much of the support of the alternating current, has in some way or other found vent in altogether too

1. Read before the Chicago Electric Club, June 4, 1888. The seventh of a series of papers upon the subject, "The Continuous *vs.* The Alternating Current," before the club.

windy and extravagant claims for that method of electrical distribution. No doubt the intimation will be repeated that I am closely allied to the parties controlling the leading constant current system of incandescent lighting, but such is not the fact. I am not connected nor in any way authorized to speak for that system. The representatives of that interest who are members of this club are quite able to do that for themselves. I am indeed prejudiced in favor of the Edison system, but am not unwilling to give credit and recognize the very valuable work done by the other inventors. It is hard, however, for me to forget that portion of the history of incandescent lighting with which I was closely identified.

I well remember when there was no incandescent electric light used in the United States. When Mr. Edison had satisfied himself that the (so called) subdivision of the electric light was economically and commercially possible, his public announcement was greeted with derision by high authorities in this and foreign countries. In the light of subsequent developments most of these gentlemen generously acknowledged their error. In like manner, I shall claim the privilege of stepping off the track, if the locomotive represented by the alternating current shall threaten to run me down. The unanimity with which the arc light companies first derided and subsequently grabbed for the incandescent business always refreshed me as a striking illustration of the prevalence of electrical "cheek." The avidity with which they are now rushing to the alternating current makes me fear that their experience with the constant current has not been sufficiently profitable to satisfy their vaulting ambition.

Early in the development of the Edison light I had the exquisite pleasure of attending Professor Morton's famous lecture to the members of the national gas convention at the Stevens institute, in which he so ridiculed Edison's proposed division of the electric light that his audience was overcome with the utmost hilarity. The gas interest has since that date had abundant cause for reconsideration, and at last, aided by hard knocks and inherent practical business sense, has come to the conclusion, in many instances, that the electric light is a good thing, which they will own themselves. I pioneered the incandescent electric light in Chicago, although closely followed by my friend, Mr. Warren, who has since always been able to keep anyone from feeling lonely in the business, and it is no small gratification to me that some of the men who were most violent in opposition to the incandescent light have since fitted up their buildings with it, and even made large investments in electric lighting enterprises. Having actively participated for four years in the early introduction of the Edison constant current system of incandescent lighting, and being somewhat familiar with its steady and successful subsequent progress, I am not prepared to rashly follow the lead of others into the alternating system until certain that it will not lead to disaster. We have had these bursts of enthusiasm in the business before, of which the premature efforts at the introduction of storage batteries are a striking illustration. I believe in proving all things and holding fast to that which is good, rather than rashly take up what in comparison can only be shown to have a promise of success. Now let us see if we can find a few shreds left upon which to hang our belief that the constant current system of electric distribution is still entitled to preference as against our mortal enemies who seek to overwhelm us with the alternating method.

Not having even attempted to figure a system of electrical conductors for nearly three years, and my attention having since been largely turned in other directions, I shall not attempt, after the able expositions of the learned and more experienced members of the club, who have preceded me, to treat the subject from a scientific standpoint with fancy diagrams by way of illustrations. I shall be compelled to confine my attention largely to the commercial side of the question, but as Mr. Edison has often said, "Any invention which is not commercial is N. G.," and as we claim the constant current system is commercial, in that it now returns a profit to the investor where ordinary good judgment, practical skill and management is employed, something may still be found worthy of consideration from my point of outlook. Considerable has been said in the progress of this discussion upon the subject of electrical engineering ability.

In the electric field I know of no undertaking more brilliant in conception, audacious in execution and successful in operation than the first district station of the Edison Illuminating Co., in New York city. At the time it was planned electric incandescent lighting was generally believed to be impracticable. The lamp, dynamo, underground conductors, meters, regulating apparatus and various appliances had to be perfected and to a large extent devised. This constant current low tension system was installed in the financial centre of this country in the teeth of the most powerful gas companies in the land, and in a district where the buildings are largely vacated at night, so that the amount of light required is relatively small. The light was to be sold by meter, and had to win its way not only in competition with gas, but with other forms of electric lighting. Croakers prophesied that the system would not work; when it did work that it would not endure, and when it endured that it would never pay. It will be five years in next September since current was first turned on the system, and with the exception of two hours on a single occasion when the safety catches in the feeders burned out from insufficient capacity, there has not been a single instant, night or day, when the current supply has failed. When some of the alternating current stations with their dynamos and single pairs of conductors have made a record equal to this, the capital invested may begin to feel secure, for constancy is a prime factor in electric lighting. The means employed for regulating the light have been found reliable and satisfactory. Not the least interesting feature in connection with the operation of this system to me is the means employed to locate faults in the underground conductors by tests at the station while current is flowing over them. It is not unusual to locate from the station within a few feet of the spot where the fault exists. Although the Edison tubes in use are the first manufactured, they have proved reliable in the main and are in good condition. The meters give correct measurement of the current used, and customers pay their bills. 11,000 16 c. p. lamps are daily supplied from this station. Although this is the first large incandescent system ever put into operation, and although the installation was made on the two-wire 110 volt multiple method at a cost certainly double and perhaps treble what it could be duplicated for to-day, the investment is profitable. This success has resulted in the capital being furnished largely by the original investors for the four Edison stations now being installed in New York with an aggregate capacity of 150,000 lamps. A gentleman of large electrical and business experience, who recently rigidly examined the books of the Edison first district in New York with the view of a considerable investment of his money in the Chicago Edison station, which investment he decided to make, assures me that the station is earning 8 per cent. upon its capitalization. It is interesting to note that the Chicago Edison station which is now being erected here will have capacity for 50,000 lights instead of 30,000, as originally intended. The money furnished for this work comes largely from parties who have been interested in the Edison business in the west for several years past. The large Edison stations in Boston, Philadelphia and elsewhere ought to convince any fair-minded man that profit is to be realized in the use of a constant current low tension system. Capitalists as a class do not transact business on a sentimental basis, and if our alternating friends shall be so fortunate as to scoop the present investors in the constant current system by a competitive system, we need not waste much time in sympathy and lamentation. We, as members of the dear public, may get some benefit in the price at which light can be had. My only suggestion is that our alternating friends hurry up, for operations in the Edison constant current system are in early contemplation, which, for the amount of capital involved, rivals the Chicago gas trust syndicate. An established electric light industry is a hard thing to unseat, and time, experience and readiness for operations are valuable elements toward early success. I consider it conclusively demonstrated beyond cavil or dispute that capital invested in Edison constant current installations in large areas of compactly built cities under the most adverse circumstances in the present state of the art will form a profitable investment.

As the opinion prevails to a considerable extent that the alternating system presents peculiar advantages for small towns or cities with a scattered population, I will cite only one instance in favor of the continuous current 3-wire Edison system. The city of Laramie, W. T., has a population of 6,000 people, and fairly represents the average place of that size. There is now in operation at that place an Edison station supplying 4,000 lamps. A personal friend who invested some money in this station largely upon my advice, informed me that it is paying him 10 per cent. This earning has been made until recently exclusively from the sale of current for incandescent lighting, the station being a little over two years old. Early in the present year the sale of current for use in supplying power was commenced, and the prospect is that within the present year the income from this source will equal if not exceed the income from light. I will instance one or two customers to whom current for power is sold. The Laramie Milling company is supplied with current for two 25 h. p. Sprague motors. It is a modern roller mill with the capacity of 100 barrels of flour per day. There is no boiler or engine about the institution. For reasons connected with the manufacture it was decided to use two 25 h. p. motors instead of one of 50 h. p. The manager of the mill says the power is satisfactory in every way, and as constant as the best regulated automatic engine. He enumerates the following advantages: Ease in placing the power where wanted, and thus avoiding long lines of the shafting or more objectionable belts; economy of room for power plant; saving of first cost of power plant, interest and taxes; 30 per cent. saving in insurance rates; an economy and increased reliability over steam power for his use. It may be unfair to the Edison interest to give away to our alternating current friends the price which is paid for the power, but in this case I am going to risk it. The average load on these two motors is 23,000 watts, and the price paid is $292 per month of 26 days, ten hours per day.

The Laramie Edison company also supplies current to a rolling

mill for a 20 h. p. Sprague motor. Power is communicated from the motor to 120 feet of three-inch shafting. This shaft drives four spike machines, two bolt headers, two nut pressers and a large number of threading and tapping machines, including some emery heads. The average load is 11,250 watts for twenty hours a day, which is paid for at the rate of fifty cents per hour. The mill was formerly run by steam power at a larger cost, and in not nearly as satisfactory a manner. These mills are supplied with current directly from the regular feeders of theEdison station. In addition, the Laramie company is selling current for a number of smaller motors. Already the income of the company is at the rate of over $6,000 a year from the sale of power. These statements are made upon the authority of R. M. Jones, the manager of the Laramie Edison company. This illustration furnishes conclusive proof that the Edison constant current, 3-wire 220 volt system in cities of the smaller class, can be made profitable.

It is appropriate at this point to give the question of the sale of current for power from electric generating stations additional consideration. This branch of the business has already acquired magnitude, and is destined to grow into gigantic proportions. The maximum lighting load of a station is seldom carried for more than from two to three hours in the twenty-four. During the remainder of the day there is a large surplus capacity in boilers, engines, dynamos and conductors, which must remain idle unless employed otherwise than in supplying current for light. The sale of current for power comes in to fill this gap as it is needed largely at a time when light is not required. The sale of a single electrical horse-power of energy for ten hours is equivalent to the sale of 48 16-candle lamps for three hours, which would be a large average burning. It is a fact where the Edison stations are run day and night that the current sold for power exceeds the current sold for day lighting. and in many cases it is rapidly growing toward an equality with the entire sale of current for light night and day. I will give one example of what an Edison station can do in a city of the medium class.

The Detroit Edison station is now supplying current for about 9,000 lamps, and they are behind their orders for installations to the extent of several hundred more. In regard to the sale of current for power it is supplied as follows: Printers 6, newspapers 1, opticians 1, laundry 1, chemical works 2, wire works 1, shoe manufacturers 3, bookbinders 1, machine shops 2, telephone companies 1, knitting works 1, hydraulic elevators 3, elevators 3, sewing machine shops 5, dentists 6, jewelers 3, ice cream dealers 1, sporting goods 1, ash elevators 1, storage boilers 1, also quite a large number of small motors for single fans, sewing machines, etc. The party taking the largest amount is the Detroit *Tribune*, 30 h. p., and the knitting works take 15. The present aggregate sale amounts to 162 ½ h. p., which at $100 per year makes an income of $16,250, which is not to be despised. In view of such a source of revenue which is available to the constant current system, I cannot avoid the conviction that the capitalists should use extreme caution in investing his money in alternating systems which so far are only able to promise a successful motor for use in connection with their current in the dim hereafter.

A great hullabaloo has been made in this discussion about the cost of copper in connection with the constant current system. In the territory which it is the custom to attempt to cover with the Edison system the cost of copper seldom equals 20 per cent. of the entire cost of the installation. As the constant current has unrivaled capacity for producing revenue within the territory covered, it certainly ought to be greatly preferred even if there was a large margin of cost in copper against it. I will give one or two examples of what the actual cost is for copper in a couple of Edison stations now in process of installation. For one installation which provides 100 street lamps scattered over an area of 1½ miles square and 500 lights for stores, residences and churches in a mile square, the entire cost of copper at 20 cents per pound is $3,000 or $5 per lamp. For another installation where 100 street lamps are scattered in one area two miles square and 800 inside lights in an area about a mile square the entire cost of copper at 20 cents a pound is $3,102, or $3.44 per lamp.

I have not as yet seen or heard a satisfactory answer to Mr. Leonard's statement of the comparative cost of the conductors of the two systems when converters at $3 per lamp are taken into consideration for average practical installations at reasonable distances. As Mr. Leonard has already stated, the load diagrams of the Edison stations show that the maximum number of lights burning at one time is only 40 per cent. of the number of lamps actually installed. I want to emphathsize the point that conducting capacity in the feeders and mains is only supplied for the highest number of lamps carried at one time, and yet in any one building all the lights may be in service at once. Therefore, conductors must be supplied for the full lamp capacity. On a general Edison installation with conductors for, say, 1,000 lights, 2,250 lamps may be installed in the buildings. The investment for converters from this standpoint is enormous. Parties engaging in the electric lighting business presumably do so with a view to doing the great bulk of the lighting in the territory covered. I do not suppose over ten per cent. of the gas jets in Chicago are ever lighted at one time. The party undertaking to supply converter capacity for a number of lamps equivalent to the gas jets in Chicago will have an investment on his hands sufficient to appall any one who is not swayed by an imaginary advantage.

Criticism has been made upon the constant current station on account of the amount of apparatus it contains. For my own part I greatly prefer apparatus located at a central point, in the hands of competent employés to keep it in order, to scattering a lot of converters all over creation where they will necessarily make a great of trouble. Any one who has had experience with electric appliances in which insulated wire is used and through which powerful currents pass, whether it be telegraphic, fire alarm, electric light, or any other form of apparatus, knows that it is liable to frequent troubles, and when converters are placed on poles or the exterior of houses, or even in the interior of houses where they necessarily must often go in damp places, the claim that they will not need frequent care and attention is certainly all bosh. Moreover, in many of the latest Edison stations feeder equalizers are dispensed with altogether, so that switches, ampere and pressure indicators constitute the sum total of the special appliances.

It is just as easy to run constant current generators with a separate exciter for the fields as is the case in the alternating system, so I fail to see any special force to that argument except that it is not usually done. The advantages to my mind of being able to multiple-arc dynamos, and of having a number of feeders supplying a common system of distributing main conductors is very great. The auxiliary conductors used in connection with the alternating system bring up the cost for copper in a measure, and add to the complication of their circuits. The objection which has been urged to the operation of two classes of apparatus in the same station will hardly hold so long as our alternating friends find it necessary to use constant current dynamos to supply the arc lights operated from their stations. I am still unable to see any special advantage for the 50 volt lamp, which is claimed to be specially adapted for alternating work. It certainly increases the size of the inside wiring as compared to the 110 volt lamps, and places that part of the alternating installations in antagonism to the principle which is claimed to be so advantageous in the exterior conductors. No doubt lamps of the same voltage from different manufacturers will vary considerably in results.

A recently published article in regard to the incandescent lamps, written by John W. Howell, who is a high authority, says that lamp renewals should not exceed 15 per cent. of the operating expense of a central station plant. I am not aware that the cost of Edison 110 to 120 volt lamps exceeds this figure, nor that the Edison company is unwilling to guarantee an equal number of lamps to the horse-power and an equal life with any other lamp in the market.

An admirer of our friend, Mr. Cutter, says he always likes to hear him talk. I confess that during the progress of this discussion Mr. Cutter has helped me to understand how it is that the Thomson-Houston company secured such a large slice of the electric business, for his talk is very plausible. As against his theory that the eye judges the light at the instant of maximum incandescence when the impulses are in the lamp, and hence that the alternating current may be more economical than the constant current in the incandescent lamp, I want to suggest that the successive impacts of the alternating current must have a tendency to impair the structure of the carbon, for in my experience rapid changes in current have been a fruitful cause of brevity of lamp life.

I must also take exception to Mr. Cutter's view that a conduit system with small ducts through which conductors can be hauled from time to time between man-holes located at convenient distances is the most desirable. The experience with this system in Chicago certainly does not bear out this conclusion. If with a high tension alternating system it is going to be necessary to have new conductors hauled in every few days because those in use burn out, I can understand part of the necessity for such a construction. How such a conduit system is adapted to an electric distribution from which taps must be taken every few feet in order to enter buildings, is not clear to me.

Considering the expense, I still believe the Edison system of underground conductors, all things considered, the best which has yet been devised for incandescent work. It is easy to increase the thickness of the iron casing if the soil makes it advisable to do more than guard against mechanical injuries. I am aware that the Chicago troubles with the high tension underground conductors have been greatly lessened recently by a heavy increase of the insulation employed. This is a fact which stares the alternating current in the face. Large first cost for insulation and constant care and expense to maintain apparatus to prevent an undue percentage of waste in the current supply. The feeders in an Edison 3-wire system are usually figured at 10 per cent. loss, the distributing mains at two per cent., and the inside wiring, at the same, or a total of 14 per cent., under conditions of full load. As has been stated, the percentage of loss of current in the conductors is proportional to the load, so that the average loss is much smaller, say, five or six per cent. With the alternating current the opposite is exactly the case, for the converter has its

highest efficiency with the maximum load, but runs down materially as the load decreases. The alternating current system being practically confined to the sale of light for the present, and the maximum capacity of the converters being seldom called into use in a general lighting system, the advantage seems to be against it for economic use for distances which the constant current system attempts to supply.

I have always been strongly in favor of selling current for the incandescent light by meter measurement, and thereby profiting from the long experience of the venders of artificial gas. I am well aware that there are Edison central stations selling light by the contract system which earn 20 per cent. on their capitalization, but such cases are exceptional and it is my conviction in the long run that method will not be found satisfactory either to the customer or the companies. There are now thousands of Edison meters in successful use, and until the alternating companies shall perfect a meter and put it into extended use, the lack of this will continue to be a great objection to that system.

Allusion has been made several times to the excessive cost of the ground upon which the Edison stations are located, and I still want to say a few words on this branch of the subject. It has been stated to the club that in Boston capital has been offered to the Edison company to erect a building sufficiently large to accommodate the station and provide enough additional room for rent to pay a handsome profit on the investment in the ground and building. Our president has suggested that as other large corporations frequently provide their own accommodations in this way, electric light organizations may do so also.

The Chicago Edison company cannot be accused of any effort in this direction, but is evidently inclined to meet its fate strictly in the line of the sale of electric energy. I desire to repeat the statement heretofore made by myself that when a station is centrally located the sale of exhaust steam for heating purposes to surrounding buildings should become a large source of revenue. In combination with the Johnson heat regulating apparatus, especially favorable results can be obtained. The Chicago Edison station already has applications for steam heat, and I have no doubt this source of revenue is to become an important factor in electric lighting stations. When a station is located in the suburbs the exhaust is necessarily thrown away.

It should be distinctly understood that I am no alarmist in regard to danger from electric lighting currents. I believe there is no electric lighting in use which begins to compare in danger to property and life with gas. Still the fact that it is thought advisable by some to ground the secondary circuits and by others to ground a metallic shield between the primary and secondary coils in the converters for the protection of customers of the alternating system is in itself a confession of danger. Either method appears to me to make a series of first-class lightning arresters out of the converters, well calculated to protect the community at large at the expense of the pocket books of the stockholders in the alternating companies. In Edison's early work on the incandescent light he frequently expressed the determination to devise a system which by no possibility could injure any man, woman or child. That was a noble ambition, and I for one shall be sorry to see for economic reasons his system for general use so modified that this element of safety cannot be claimed for it.

A gentleman connected with a life insurance company recently stated to me that his company had decided to make all employés engaged in the the dynamo room and on line work of the alternating special risks, the same as the arc light employés. This is not the case with the employés of the low tension constant current system. The public has a right to demand the highest standard of safety in electric lighting, and there have been few more commendable things done in this city than the establishment of a rigid inspection of electric light plants, vexatious as Brother Haskins sometimes makes himself. The tendency of legislation and the courts is to hold corporations to a strict accountability for losses and injuries arising from carelessness of employés, in management and construction. It will be absolutely necessary in using high tension alternating or constant currents to maintain a high standard of insulation and efficiency to avoid the assessment of heavy damages in case of accidents. In this respect the low tension constant current system has a great advantage over high tension alternating currents; even where a high tension constant current is transmitted a long distance and converted by a motor generator, there is less risk, for in case of accident at the station it would be quickly discovered and remedied by the attendant, while with the alternating current it is possible to bring a death current within reach of the individual users of the light where the danger might not be discovered until a fatality had occurred.

Mr. President, I owe the gentlemen connected with the club an apology for not having brought with me a diagram to illustrate the subject under consideration. I contemplated bringing a picture of a 15-story office building with the windows omitted and a system of converters substituted in their stead. I thought it probable from the brilliant way in which converters appear to some of us that with such an arrangement by opening them on the inside, tenants would get all the light they wanted without the aid of the sun or additional apparatus. Such an illustration would be, in my opinion, about as fair as some of the diagrams shown here of the wires which cover northern Minnesota so as to shut out the buildings in St. Paul from view. If the club will excuse my neglect in not bringing the diagram on this occasion I will promise to make amends in the future. I make this pledge all the more freely because promises and futures seem to have a current value when electric distribution is under consideration.

THE EDISON LAMP PATENTS IN ENGLAND.

THE action of the Edison and Swan United Electric Light Co., Limited, *v.* Holland and others, was commenced at the Royal Courts of Justice, before Mr. Justice Kay, April 17th, to restrain infringement of Edison's patent for the filament, No. 4576 of 1879, and Cheesbrough's (Sawyer-Man) "flashing" patent, No. 4847 of 1878. The Attorney-General (Sir Richard Webster), Mr. Aston, Q. C,, Mr. Moulton, Q. C., and Mr. Bremner, instructed by Messrs. Ashurst, Morris, Crisp & Co., appeared for the plaintiffs; and Sir Horace Davey, Q. C., Mr. Finlay, Q. C., and Mr. Graham, instructed by Messrs. Renshaw, for the defendants. These two patents have already been the subject of litigation, in the case where Messrs. Woodhouse & Rawson were defendants, and plaintiffs were successful, both before Mr. Justice Butt, in the first instance, and subsequently in the Court of Appeal. The present case is of importance, because if the defendants succeed in establishing the invalidity of those patents, the manufacture of incandescent lamps will be thrown open to the public.

The case arose as follows: Holland, purchased the lamps complained of from the Jablochkoff company, for illuminating the Albert Palace; that company purchased them under indemnity from the Anglo-American Brush Electric Light Corporation, Limited, which obtained leave to defend the action, and are therefore the real defendants. The attorney-general opened the case by describing the inventions contained in Edison's and Cheesbrough's specifications, and pointed out that among the merits of Edison's invention one of the most conspicuous was the carbonizing of the filament after it had been formed. He dwelt upon the fact that no practical incandescent lamp had been made, or described, before Edison's patent, and that soon after that date such lamps were made and sold, and have since been made and sold in millions. So far as the plaintiffs were aware, the only lamp which came at all near to Edison's was made by Mr. Swan, early in 1879 or in the autumn of 1878, at Newcastle, where it had been publicly exhibited by him at lectures. This lamp, which was produced, contained a thin straight pencil of carbon of circular section about 1¼ in long and $\frac{1}{16}$ in. in diameter, enclosed in a glass egg-shaped vessel, from which the air had been exhausted. The carbon pencil was supported at each end by platinum wires fused into the glass.

Sir Frederick Bramwell was called on behalf of the plaintiffs. He was examined by Mr. Aston, and cross-examined by Mr. Finlay, who endeavored to elicit from him the fact that Edison had not given sufficient information to enable a skilled workman to carbonize a filament, especially by reason of his having omitted to state that in carbonizing it is absolutely necessary to exclude the air from the vessel in which the filament is carbonized. Sir Bramwell stated that in his opinion the vessel might be packed with sand, to exclude the air, and that this would succeed. Sir Bramwell was asked whether he had ever seen any lamps made according to Edison's specification without additions; and although he at first stated that he had seen one lamp so made out of a carbonized cotton thread, he subsequently admitted that the thread had been treated with sulphuric acid to parchmentize it before carbonization, and that he had never seen Edison's directions pure and simple followed. Sir Bramwell was then pressed to state the advantages to be obtained from the use of a filament, and was unable to point out any except that of high resistance. The witness admitted that electricians at the date of the patent were perfectly familiar with the laws of electricity, and knew both how to obtain high resistance, and what were the advantages resulting from it; and this was more especially the case with Mr. Lane-Fox, who had explained the whole theory of electric lighting in a marvellously clear manner in several specifications of his patents taken out before the date of Edison's patent. In fact, had Mr. Lane-Fox only made use of the term carbon in his specifications, he would apparently have given all the information to the world which the plaintiffs now wish to place to the credit of Mr. Edison. The witness was asked to explain how Mr. Swan's lamp differed from Edison's. At first witness endeavored to differentiate them by suggesting that the pencil of Swan's lamp had been cut out of a larger piece of carbon, that is to say, had not been in the form of a pencil before it was carbonized; but, when pressed, admitted that Swan's pencil might have been made either way. Upon various chemical points, arising on both Edison's and Cheesbrough's specifications, more especially upon a very remarkable passage in the latter—in which Cheesbrough says that his invention is not confined to the treatment of carbon alone, but

includes many infusible non-conducting bodies—Sir Bramwell gave no opinion, preferring to leave them to the chemical witnesses.

The next witness on behalf of the plaintiffs was Dr. John Hopkinson, who agreed generally with Sir F. Bramwell except upon the question of the use of sand for excluding the air in carbonization. He thought that a competent working man would know that he must avoid using sand, the use of which would certainly lead to failure in the case of fine filaments, inasmuch as they would, without doubt, be burnt in the carbonizing vessel by the air contained in the interstices of the sand. Dr. Hopkinson expressed a decided opinion upon the chemical questions arising on the specifications of both Edison and Cheesbrough; but, like the last witness, he admitted that he had neither made nor seen any experiments on the subject.

Mr. John Imray was then called. He had not made any lamps according to Edison's specifications, but had made experiments as to the electrical properties of certain lamps made by some person in the employment of the plaintiffs, and which, he was told, had been made according to Edison's specification. Nearly all these lamps had the globes discolored. Sir Horace Davey asked the witness to point out any material point in which one of the lamps produced made from cardboard and said to be constructed according to Edison's specification, differed from Swan's lamp. The witness was apparently unable to point out any material distinguishing feature.

Mr. Gimingham was next called, and stated that he had followed precisely almost all the different methods described by Edison for making a filament, and had succeeded in the whole of them. He further stated that he had tried the lamps so made for duration, and found the average life to be a considerable number of hours.

The last witness for the plaintiffs was Dr. Fleming, the electrician of the plaintiffs, who agreed in the main with the evidence given by the others. He, however, stated that secret processes were used in every stage of the manufacture of lamps by the plaintiffs, an admission which would seem scarcely consistent with the opening statement of the attorney-general, that millions of lamps were made by the plaintiffs according to Edison's specification.

Mr. Aston stated that that closed the plaintiffs' case.

Sir Horace Davey then opened defendants' case. He said that he intended to rely upon the following grounds, viz., that Edison's patent was bad for want of novelty; that his specification did not contain sufficient directions to enable a competent working man to make a filament of carbon; and that if the Court construed the specification in the way in which he construed it, there was no infringement, but if construed as the Court of Appeal had construed it he would admit infringement. Lane-Fox's patent, taken out in October, 1878, contained a statement of the principles which lie at the bottom of a successful incandescent lamp to be used in a system of parallel distribution. It was there stated that the lamp must have a high resistance, and that the electromotive force must be considerable, say about 100 volts. A subsequent specification of Lane-Fox's was also referred to, which came very near Edison's, except that Lane Fox, instead of saying "I make use of carbon," had stated that he used certain metals "or other suitable material." Sir Horace Davey then passed on to the consideration of Swan's anticipations, and said that he hoped to prove, that from as early as 1877, but certainly from 1878, Swan was engaged at Newcastle, with the assistance of Mr. Stearn, at Rockferry, near Birkenhead, in making incandescent lamps, and that he succeeded in making not only lamps with straight conductors, but with more or less filamentous conductors, in some cases from carbonized paper. Speaking of the "stick" lamp produced in court by the Edison company, the one frequently exhibited by Swan at lectures before the date of Edison's patent, Sir Horace said: "It cannot be denied, and I think it never has been denied, that this lamp is identical with Edison's specification, unless you can distinguish it on the ground that this carbon conductor does not come within the description of what Edison meant by a filament." It had been said by the plaintiffs that it was a lamp of low resistance, three to five ohms, and no doubt it was so, although its exact resistance could not now be ascertained, for after a "litigious" life of 10 years, the carbon had become damaged. The lamp was composed of a straight stick of carbon about 1¼ in. long and $\frac{1}{16}$ in. diameter, mounted between two platinum wires in a glass globe, from which the air had been exhausted. The globe was considerably dimmed by deposited carbon. The occluded gases had not been removed by Mr. Swan when he constructed the lamp in 1879. Sir Horace Davey then proceeded to point out the main lines of attack which he proposed to make on Edison's specification. He said that Mr. Edison had added nothing to the stock of knowledge possessed by the public in 1879; that he had not given sufficiently clear and definite instructions to enable a skilled workingman to make a lamp without considerable experiment; that he had in fact done nothing more than make a series of suggestions which he had not worked out in his own mind, but had left to be worked out by subsequent experimenters; that the mere statement that a combination of a carbon filament within a receiver entirely of glass through which the leading wires pass, and from which receiver the air is exhausted (Edison's second claim), was nothing more than a statement of a desirable object which electricians had in view. Sir Horace then went on to discuss the meaning of the word "filament," and pointed out that the witnesses who had been called for the plaintiffs had been unable to give anything like an accurate definition of a filament, and would not commit themselves by stating where a filament ended and a pencil began. He should argue that Edison had deliberately abstained from making his meaning clear, and that a patentee was rigorously bound in law to put up such a fence that everyone coming within that fence would be coming upon forbidden ground, and Edison had erected no such fence. Sir Horace then dwelt on the fact that, with the exception of a few lamps made for use in the former action against Messrs. Woodhouse & Rawson, and in this action, plaintiffs had not been able to produce a single lamp made according to the directions in Edison's specification without the addition of other processes or improvements, although the counsel for the plaintiffs and their scientific witnesses had spoken of the world-wide Edison lamp which had created a revolution in electric lighting. Edison himself had taken out several subsequent patents, in two, at least, of which he had given further instructions in the processes of manufacture. In one of these he had stated that purely structural carbon was the only carbon which would answer; the greatest possible condemnation of that portion of the specification in question which claimed filaments made by carbonizing lamp black and tar. He then proceeded to cite certain decided cases, which, he contended, showed that Edison's specification was invalid.

Sir Horace Davey then went to the other patent, viz., Cheesbrough's, which is a patent for an invention made by Messrs. Sawyer and Man, in America. The invention consists in placing the filament in a vapor of hydro-carbon, and then passing the electric current through it, so as to raise the conductor to a yellow heat. At that temperature the hydrocarbon is decomposed, and carbon is thrown down in a very beautiful manner upon the filament, the deposition taking place most rapidly at those points on the filament where the temperature is highest, which are the places where the filament is thinnest. By this means a filament of uniform electrical section is rapidly obtained. Sir Horace Davey stated that the anticipation upon which he intended to rely chiefly was a paper published by the eminent French chemist, M. Despretz, many years ago. M. Despretz had been anxious to ascertain whether he could fuse or volatilize carbon. He had placed carbon in the electric arc, and he had also passed a current of electricity through the carbon, and in the course of his experiments he had surrounded the carbon with nitrogen; but he found that some chemical action took place between the carbon and the nitrogen, and he then hit upon the idea of placing the carbon in a hydrocarbon atmosphere. To his astonishment the hydrocarbon was decomposed, and carbon was deposited not only on the piece of carbon operated upon, but also on the clamps in which it was held, and on the glass vessel containing them. Sir Horace also stated that he intended to rely upon that passage in Cheesbrough's specification in which he stated that his invention was not confined to carbon alone, but included many other infusible non-conductors, as for example lime.

Robert Percy Sellon, the chief electrician of the Anglo-American Brush Co., was called for defendants. He described the process by which the Brush company had made the lamps complained of. That process, which is to some extent covered by patents, consists in taking cellulose in a pure condition and dissolving it in chloride of zinc, producing a jelly-like substance, which is forced through a small circular aperture into alcohol. The effect of the alcohol is to cause the cellulose to deposit in long fine homogeneous threads, which are very carefully dried on velvet, and then wound upon moulds the shape of the filament when finished, and the whole placed in carbonizing crucibles, packed with charcoal, and raised to a high temperature, care being taken to exclude the atmosphere, and to allow for the contraction of the filaments during the process of carbonization. The filaments are then mounted in clips and flashed for a few seconds only, so as to bring them all to the required resistance. The filaments are next mounted on the platinum wires, by again flashing the surfaces where the carbon and platinum touch, and are then ready for mounting in the lamp and for having the globes exhausted and the occluded gases taken out. Mr. Sellon was examined at some length as to the insufficiency of the directions in Edison's specification, and especially as to carbonizing, and the injurious effect alleged to be produced on the platinum leads by putting them into the carbonizing chamber in those cases where the filaments are mounted to the platinum before carbonizing. Mr. Sellon was then cross-examined by Mr. Aston, and admitted that in one or two of the papers in evidence in the case there were directions given for putting powdered charcoal into the crucible when carbonizing carbons to be used for arc lighting, especially in a description of the process adopted by M. Carré.

The next witness was Professor Crookes, who was examined by Mr. Graham. He described very minutely a large number of experiments which he had made upon the directions contained in

Edison's specification, and which he had found the greatest difficulty in following, having failed to produce a lamp of any commercial value by any of them. Professor Crookes also described some very remarkable experiments which he had made upon that portion of Edison's specification where it is stated that the filament may be coated with some non-conducting non-carbonizing body. He coated the filament with asbestos, fire clay, and other similar substances, and found that at temperatures below those which are usual in a lamp, a chemical reaction takes place between the carbon and the oxygen in those substances, the carbon burning off as carbonic acid. Professor Crookes had also made similar experiments with respect to the passage above referred to in Cheesbrough's specification. He took a small pencil of carbon, and surrounded it with lime, and passed the current through the carbon, while it, with its lime envelope, was surrounded by a hydro-carbon gas. Carbon was deposited throughout the pores of the lime. The witness then cut a small pencil out of the lime, impregnated with carbon, and mounted it in a lamp, which was then exhausted. When the vacuum was as good as that usually obtained in lamps, Professor Crookes passed the current through, and before the usual lamp temperature was reached a reaction commenced. The filament began to scintillate, and broke down immediately. Experiments of a similar character were made with magnesia and other bodies with similar results. Professor Crookes was cross-examined at great length by the attorney-general, and admitted that many of the references in Despretz's experiments were made with the arc phenomena and not with incandescent carbon.

In reply to further cross-examination, the witness referred to several passages in Edison's subsequent patents, in which was pointed out the necessity of careful carbonization to prevent warping, twisting, etc., and to allow for contraction, which he stated to be inevitable; and speaking of Edison's suggestion to coat the filament with a non-conducting non-carbonizing substance, he pointed out that the action of these substances upon the filament when placed in the lamp would depend to a very great extent upon the condition of the filament itself. If the filament were a hard homogeneous carbon, and the silicate easily fusible, the silica might run off without attacking the carbon, whereas, if it were a soft porous carbon, it would absorb a fusible silicate like a sponge, and be destroyed when the temperature rose high enough. A lamp handed to Professor Crookes by the attorney-general, which had been coated with a non-conducting non-carbonizing substance was, in Professor Crookes's opinion, made with a filament of thread treated with an acid prior to carbonization. He did not consider this a fair example of the Edison filament described in the specification. He also stated that he had himself experimented with a very large number of substances as coatings for filaments, and without a single exception had found them all the reverse of beneficial, by reason of their diminishing the radiating power of the carbon. Returning to the subject of carbonization, it had been suggested to the witness, in cross-examination by the attorney-general, that gases were given off during carbonization, and expelled the air from the crucible. On this point Professor Crookes stated that at the comparatively high temperature at which these gases would be formed, the mobility of the molecules would be much increased, and they would diffuse out rapidly at the same time that the atmospheric air would diffuse in: the luting of the crucible would by this time have become quite dry, and permeable to gases.

The next witness called by the defendants was Dr. Frankland. He stated that he lighted his house five or six years ago with incandescent lamps obtained from the Swan company before their amalgamation with the Edison company. He remembered the exhibition of lamps at Mr. Spottiswoode's house in December, 1880, on which occasion Mr. Swan explained their construction. The first time he saw an Edison lamp was at the Crystal Palace Exhibition in 1882, when Mr. Sprague, Mr. Edison's agent, presented the witness with an Edison lamp, which he produced. This, in Dr. Frankland's opinion, was made of a bamboo filament, and not according to the directions contained in the specification now in question. The carbon filament appeared to have been mounted to the platinum leads by some electrolytic process, and the witness had never seen, in the market, an Edison lamp in which the filament was mounted in the manner described in the specification. Dr. Frankland stated that he had endeavored to make a putty-tar filament, but had not been able to roll it out finer than one millimeter in diameter. He did not attempt to carbonize any of these filaments himself; but he saw an experiment made by Professor Crookes, in which the crucible had not been packed, and all the filaments, including some made of structureless cellulose, were entirely burnt up, leaving nothing but ash. He corroborated Professor Crookes as to the effect of coating the filament with the non-conducting non-carbonizable bodies, and also as to the effect which the carbons would produce on the platinum if the platinum were attached to the filament before carbonizing. In his opinion, at the date of Edison's specification, the word filament had acquired no technical or conventional meaning, except in botany, and there it meant, in some cases, a thing of considerable diameter as compared with its length. Speaking of the experiment which Professor Crookes made, where a fine pencil was cut from a stick of lime, which had been impregnated with carbon by flashing in a hydrocarbon gas, and the pencil then placed in a lamp, Dr. Frankland stated that he was looking through a spectroscope at the time, and after a minute or two he saw the calcium hues in the spectrum; soon afterwards the lamp broke. He had carried out Despretz's process, and produced a material identical with Cheesbrough's. If the platinum had been placed in the carbonizing chamber, and had thus to some extent been converted into a carbide, then at the time of sealing the platinum into the glass a considerable length of the platinum would be heated to a red heat, and the carbon in the carbide of platinum would burn off, leaving the wires in a very porous state. Dr. Frankland was then cross-examined at length by the attorney-general. The witness was the principal scientific witness in the action brought by the present plaintiffs against Woodhouse & Rawson. He admitted that the only experiments which he had seen since that trial were those performed by Professor Crookes, and further that during that trial he had not said anything about the insufficiency of Edison's specification, or on the point which had been raised recently about the formation of carbide of platinum. The witness had stated at the last trial that in an old specification filed by Pulvermacher there were sufficient directions to enable a skilled workingman to make a carbon filament such as Pulvermacher describes; and he admitted that he was still of the same opinion, but that more specific instructions would be required to enable a workingman to carry out the process, because carbonization, so far as it was known at the date of Edison's patent, always meant partial combustion of the thing being carbonized. Dr. Frankland was then asked by Sir Richard Webster whether he was not aware that in February, 1880, there was an exhibition of Edison lamps in Queen Victoria street, on which occasion Dr. Fleming explained their construction. Dr. Frankland stated that he was not. The witness was then asked about the experiments with the lime pencil impregnated with carbon, and admitted that he had not made the experiments for himself, but was present when Professor Crookes carried them out. He said that the bright calcium hues were due to the metal calcium being in a state of vapor, and that calcium would only pass into that state at such high temperatures as that of the electric arc. On re-examination, Dr. Frankland stated that the list of infusible non-conducting substances previously referred to as having been put in by Professor Crookes, specifying some 40 or 50 bodies, did not by any means exhaust the number of bodies answering to that description, but was a list of those most likely to succeed, although in his opinion not one of them would succeed. He added that this point on Cheesbrough's specification, and the analogous one as to non-conducting non-carbonizable bodies mentioned in Edison's specification, was not referred to at the last trial, on which occasion the sufficiency of Edison's and Cheesbrough's specifications was hardly mentioned.

Dr. Tidy, who had given evidence on behalf of the plaintiffs as to Cheesbrough's patent at the last trial, was examined on behalf of the defendants. He stated that he had put 50 filaments into a crucible, and carefully luted the top and raised it to a carbonizing temperature, and had found nothing but ash on opening the crucible. He then filled the crucible with charcoal, and succeeded. He then tried making putty-tar filaments, and pointed out that Edison gave no directions as to the proportions of tar and lamp black. If you put too much tar, the mixture ran; if you put too little, the substance came to pieces. After a great many trials he got a filament about $\frac{1}{16}$ inch diameter, which he carbonized with charcoal; but he found, on opening the crucible, that it fell to pieces. He considered it was necessary to use a mould in carbonizing, which would allow for contraction and prevent distortion. Dr. Tidy was then cross-examined by Mr. Aston, and admitted that it was possible to carbonize a cotton thread, but denied that a putty-tar filament could be subjected to a carbonizing process, and come out as a filament, which could be used. Dr. Tidy had also coated a thread with tar and lamp black, and he had found that the coating cracked in carbonizing. He admitted that in one of the specifications prior to Edison there was a description of carbonizing carbons to be used for arc lighting in contact with powdered charcoal. Dr. Tidy stated that in carbonizing there were two factors which had to be taken into account: the temperature at which the carbonizing was effected, and the rate at which the temperature was raised.

Professor Silvanus Thompson was the next witness. He was examined by Mr. Finlay as the principal witness to speak to the electrical aspect of the case. Professor Thompson stated that he visited the house of Mr. Stearn, at Rockferry in the autumn of 1880, and observed that it was lit with electric lamps, the conductors of which were of a filamentous character. He saw many Swan lamps at the meeting of the British Association at York, in August, 1881, and the first time he saw an Edison lamp was at the Paris Exhibition, in September, 1881. Those lamps, he said, would come within the second claim of Edison's specification, but had been made with many improvements not mentioned in that specification. He pointed out nine respects in which they

differed from those described in the specification. Professor Thompson then produced diagrams showing the different ways in which lamps could be used, that is to say, in series, in multiple arc, and in a combination of the two. And he explained that the advantage of high resistance in lamps was an advantage external to the lamps; a lamp of low resistance being more durable than one of high resistance. With high resistance lamps small mains could be used, whereas with low resistance lamps the mains would be large. The witness referred to passages in Lane-Fox's and Edison's patents prior to the one in question where this had been pointed out, and to a specification of Edison, in which he had himself pointed out the advantages of low resistance lamps in certain cases. He produced specimens of Carré carbons which he bought from Mr. Carré in 1878, which were one millimeter in diameter, and had originally been one meter in length, and said that at that time they were the most suitable forms of carbon for use in incandescent lamps. Professor Thompson further stated that the real difficulty of fusing platinum into glass depended upon the glass and not on the platinum. Glass differs much in its rate of expansion, and if a glass is taken which has the same rate of expansion as the platinum, there is no difficulty in sealing platinum wires into it. Professor Thompson was cross-examined by Mr. Moulton, and was much pressed for the purpose of elucidating from him that the pencil of lime impregnated with carbon and put into a lamp by Professor Crookes, was not of uniform section, and that the consequence of this would be that at those portions of the pencil where it was thinnest, the heat might have risen to that due to the arc, while the other portions were still at a low yellow heat, and thus a chemical reaction between the lime and the carbon might be induced at one particular spot, while the rest of the pencil appeared to be at a low temperature.

The next witness was Professor Perry, who stated that one of the great factors which made incandescent lighting possible was the improvement in the dynamo machine. The first Gramme dynamo brought into England was shown by the witness to a number of scientific gentlemen in 1874, to whom the machine was quite unknown. In 1878, Brush took out his patent for compound winding, but the merits of compound wound machines were not generally recognized until a year or two after that date. Professor Perry stated that in his opinion it would not have been safe, having regard to the nature of the dynamos then in the market, to use a lamp with a carbon conductor much smaller than that used by Mr. Swan. The advantage of the compound winding was pointed out to be that you may switch on a hundred lamps or more, and switch them all off but one, without producing any material difference in the electromotive force. Professor Perry was cross-examined by the attorney-general, and said that he thought the gold medal which was awarded to Mr. Edison at the Paris Exhibition was not for his lamps alone, but for his telephone, phonograph, and other things also.

Mr. James Swinburne was then examined by Sir Horace Davey. He stated that about 1881 he was with the Swan company at Newcastle, and that great difficulty was experienced in properly carbonizing the filaments. After some weeks of experimenting, the method had been devised of winding the threads on such a frame as that spoken of by Mr. Edward Gimingham. At one time the Swan company carbonized each filament separately in moulds. Mr. Swan, towards the end of 1880, had taken out a patent for carbonizing filaments in powdered charcoal. Mr. Swinburne had tried long ago to carbonize in sand, and had failed, and quite recently he had measured the quantity of steam and air which came off sand, and he found that 140 cub. cm. of silver sand gave off as much steam and air as would burn up 25 to 50 filaments. A sample of grey sand tried by Mr. Swinburne of the same volume, gave off 27,000 c. m. of steam and air. Mr. Swinburne stated that he had considerable experience in testing incandescent lamps, and that he did not think the duration tests which had been made by Mr. Gimingham had been sufficiently hard ones. Mr. Gimingham had tested the lamps at about 16 watts per candle-power, whereas Mr. Swinburne considered $3\frac{1}{2}$ to 4 watts a more satisfactory test. It was the one which he usually applied.

Before proceeding to cross-examine Mr. Swinburne the attorney-general stated that he was willing to admit that the carbon conductor in Swan's stick lamp had been made by Carré, in Paris, and had received its present form before carbonization. It will be remembered that in the former trial against Woodhouse & Rawson, Sir Frederick Bramwell stated that, to the best of his belief, this carbon had been worked down from a thicker piece, and not carbonized in its present form, and in this opinion he was corroborated by the other witnesses for the plaintiffs. Mr. Swinburne was then cross-examined with a view to show that if the material used in carbonizing contained such a large quantity of sand as he had spoken of, the steam would have driven all the air out of the crucible before the temperature had been reached at which the air would begin to combine with the carbon.

Mr. Alexander Bernstein was then examined by Sir Horace Davey. He stated that he had sold large numbers of lamps in which the carbon was $\frac{1}{16}$th of an inch in diameter and from $\frac{3}{4}$in. to $2\frac{1}{4}$in. long, and that they were used in series with perfect success, especially in the United States. When he went to America in December, 1880, he could find no Edison lamps on the market; but on visiting Mr. Edison at Menlo Park he found him making lamps with filaments of bamboo. On being cross-examined by Mr. Aston the witness mentioned one or two places where his lamps could be seen in use in this country, but declined to name any others. Mr. Justice Kay intimated that the witness's objection was natural, as he was possibly afraid that Mr. Aston was laying the foundation for a case against him. This was the last witness called by the defendants on the scientific aspect of the case, the next witnesses giving evidence as to what they had seen in Newcastle at Mr. Swan's place of business during the years 1878 and 1879.

Mr. Proctor, a scientific gentleman, residing in Newcastle, remembered Mr. Swan exhibiting a broken lamp to the Chemical Society of Newcastle on the 19th of December, 1878. This lamp was a good deal blackened on the inner surface; it had contained a small straight pencil of carbon, which had been ruptured. Mr. Proctor had analyzed the black coating on the glass, and subsequently read a paper on his investigations. Mr. Proctor was also present at Mr. Swan's celebrated lecture on the 3rd of February, 1879, on which occasion the stick lamp was exhibited and incandesced for some time. It was worked from a dynamo and burnt steadily, giving a comparatively good light. Several hundred persons were present, and Mr. Swan explained the construction of the lamp. The witness then stated that during the summer of 1879 he had seen many lamps of various constructions at Mr. Swan's works in Moseley street, some being made of paper and some of thread; and that he had seen some of these of an arched or horseshoe form, which must have been carbonized after they had received that form. These lamps were incandesced in Mr. Swan's works, and gave out 10 to 14 c. p. Mr. Proctor was cross-examined at some length by the attorney-general for the purpose of showing that his memory was in fault, and that he saw these lamps in 1880 and not in 1879.

Mr. Arthur Heaviside, superintending engineer of the postal telegraphs at Newcastle, had known Mr. Swan very intimately during the years 1878 and 1879, and had tested a number of lamps for Mr. Swan in the summer and autumn of 1879 for the purpose of ascertaining their resistance. The lamps contained thread-like burners in some instances, and in others flat strips of carbonized material bent into an arched form. The witness was able to fix the date of his tests by his notes of lectures delivered to a scientific class about that time. Mr. Heaviside was cross-examined at considerable length as to the accuracy of his dates, and stated that he had not only seen threads in a horseshoe form, but also with a double twist at the end of the horseshoe.

Mr. Patterson, who carries on business at Gateshead as an earthenware manufacturer, was then called, and stated that he had on several occasions before November, 1879, taken strips of paper, packed in powdered carbon, to be carbonized in his father's pottery furnaces; and he remembered Mr. Swan exhibiting his lamps in the workshop, and at the lectures, where he on one occasion assisted in fitting up the batteries. He left Mr. Swan's employment in January, 1880.

The next witness was Mr. Mayfield, of Queen Victoria street, London, who had been the manager of Mr. Swan's scientific department until October, 1879. He corroborated the three preceding witnesses as to the experiments made by Mr. Swan in the autumn of 1879 with slender carbon burners. Several witnesses of minor importance were also called to speak to the same point, and this brought the defendants' case to its close.

Professor Dewar was then examined by Mr. Moulton, for the purpose of giving rebutting evidence on behalf of the plaintiffs. He stated that directions to enclose the filaments in powdered charcoal when carbonizing were wholly unnecessary, inasmuch as persons with an ordinary amount of skill would know that this was desirable. He produced carbon filaments which he had made by carbonizing in sand inside one crucible which he had placed in the carbonizing chamber in the inside of another crucible, and stated that none of the filaments had been attacked by oxygen, and that he had actually made a lamp from a filament of broom carbonized in that way. Professor Dewar stated that there was no difficulty in rolling out a filament of lampblack tar, and he proceeded to roll one in court to a very considerable fineness. He had mounted a filament so prepared in a lamp, and run it for a couple of hours. He had also rolled out filaments of lampblack, containing camphor and oxide of zinc, and carbonized them; but had not mounted them. The witness also produced lamps in which the filament had been coated with silicate of soda and alumina. He had conducted several experiments with Despretz's process, the result being to completely disintegrate the carbon, owing to the very powerful currents used by Despretz; and he distinguished Despretz from Cheesbrough, because the latter pointed out that it was necessary to gradually increase the current during the flashing, which point Despretz did not mention. The witness stated that Cheesbrough's directions as to his alternative process, viz., impregnating lime with carbon, were not misleading, inasmuch as, if the carbon pencil surrounded with lime were put into the lamp, the lime cylinder would not crack off,

and would do no harm. This witness was cross-examined at great length by Sir Horace Davey, and admitted that in his experiments on Despretz he had used secondary batteries, and obtained from them more powerful currents than Despretz used, and that the gradual increase of current was not essential in Cheesbrough, but only highly advantageous.

Dr. Hopkinson and Dr. Fleming were recalled to add to the evidence already given by them, the latter admitting that the plaintiffs had never made any lampblack and tar filaments except for the purposes of litigation.

The next witness was Mr. Joseph William Swan, who deposed that he had never made any thread lamps before November, 1879. He gave an extremely interesting account of his early experiments and failures. Among other things he stated that from 1877 to 1880 he worked in conjunction with Mr. Stearn, of Rockferry, who mounted the carbons in his experimental lamps, and exhausted the glass bulbs. The lamp exhibited at the lecture in Newcastle, in February, 1879, was received the night before. He admitted that he thought the carbon in this lamp received its form before carbonization. Upon cross-examination by Sir Horace Davey, he said his chief means of fixing any dates as far back as 1879 were letters which he had received from Mr. Stearn. He was then asked to explain how it was that he had been present during the trial against Messrs. Woodhouse & Rawson, in which the witnesses for the plaintiffs had repeatedly stated that, in their opinion, this stick lamp had been made by rubbing it down from a larger piece of carbon, and that he had never corrected them or mentioned the matter to the solicitors. Mr. Swan explained that he was not there as a party to the action, but merely as a person who had been subpœnaed by the defendants, and he did not then know that it was a matter of extreme importance in the action. Reports of many lectures delivered by Mr. Swan in the years 1880-1-2 were then read, in which Mr. Swan was reported to have stated that after a perfect vacuum, such as Mr. Crookes had produced, was created in the lamp, there was nothing more to be done except to perfect the details of the lamp. The attention of Mr. Swan was called to the following extract from a paper read by him before the British Association, in York, in 1881, in which he said:

> Mr. Stearn undertook to mount some of my paper carbons in a good vacuum, and after many failures from carbons breaking, we at last succeeded in making some bulbs very highly exhausted, containing my paper carbons attached by electrically-dejointed copper to platinized strips, which carried the current in and out of the lamp.

The witness was asked when this was done, and replied that it was in February, 1879. An affidavit was then read which had been sworn by Mr. Swan soon after the Edison company attacked the Swan company about the year 1882, and shortly before the two companies amalgamated and became the present plaintiff company. The words of one paragraph of that affidavit were as follows: "I believe that the said letters patent of the said Thomas Alva Edison are void, not only by reason of the prior publication of the invention claimed, but also on account of insufficient description." And finally, two specifications of patents taken out by Mr. Swan in 1880 were put to him. In the first, he described the preparation of cotton thread by treating it with acid and carbonizing it; in the second. dated five days later, he described and claimed precisely the same invention with this difference, that he used powdered charcoal in carbonizing the filaments.

Reports thus far end here. Further reports of the proceedings will be summarized in these columns hereafter.

CORRESPONDENCE.

NEW YORK AND VICINITY.

Competition among the Electric Light Companies.—The Question of Wire Distribution from the Subways.—Inspection of the Overhead Wires in the City.—The "Electric Death Chair."—Proposed Removal of "Dead" Wires.—Proposed Electric Railway in Brooklyn.—Opening of the Long-distance Public Reception Room.—A Cable Railway System to be Started in Newark, N. J.

THE competition between the various electric light companies which have recently made bids for street lighting in this city does not look very promising for those who hope to derive an income from dividends upon their stock The highest price now paid for this class of lighting is 35 cents per night, while in some districts the price is as low as 27½ cents, at which figure the Ball company was awarded 48 lamps. There also appears to be a very strong probability that these companies will soon be at considerable expense in the reconstruction of their lines to conform to the requirements of the board of electrical control. Measures have recently been taken which seem to require the various electrical companies to recognize the authority of the board, and with the appointment of an electrical expert it is very likely they will find some difficulty in framing suitable arguments to excuse them from complying with the rules of the board. The mayor, while withdrawing from active participation in its deliberations, finds time to occasionally give his views to the reporters of the daily press, and his latest stand is that the subways already provided are not suitable for the reception of electrical conductors. As no provision has as yet been made for local distribution, or the supply of facilities for connections along the various routes between man-holes, his position in that respect is no doubt well founded. An active campaign, however, has already been started against the "dead" wires, of which there are between 10,000 and 15,000 miles in the city according to various estimates. The inspectors appointed by the board are bringing in daily reports from their various districts, and the labor of complying with their requests for removal will make very active work among the linemen this summer. Even although it may not be the business of the companies to take down a large proportion of these "wild cat" wires which have been abandoned by their legitimate owners, the companies will, of course, find it to their interest to do so rather than leave the work in the hands of such vandals as the board of public works might choose to assign to that duty. It appears very probable that a similar policy may be adopted in other cities, and companies who may stand in fear of future underground legislation might do well to take the initiative in the movement. If more pains had originally been taken by the companies doing business in this city to build and maintain first-class lines their present troubles would probably never have come upon them.

Those who feel an interest in the subject of capital punishment by electricity may have their curiosity satisfied by visiting one of the Bowery dime museums which advertises among its other attractions "The Electric Death Chair." It is very probable that the design for this novel piece of furniture was taken from an illustrated article which recently appeared in a so-called journal of civilization.

The Brooklyn Heights Railroad Co., of which S. B. Chittenden, Jr. is president, has applied to the common council of Brooklyn for permission to operate an electric road through Montague street from Court street to Wall street ferry. There is also a petition before the council from the Wall Street Ferry Railroad for a cable railway franchise over the same route. Many of the abutting property owners object to this but they are interested in the other project. In the petition for the electric road it is claimed that $2,265,000 worth of property out of the $3,429,000 along Montague street is in favor of that system. Both petitions will be considered by the railroad committee.

The opening of the public room at the Telephone building, No. 18 Cortlandt street, for the accommodation of those who desire to use the long-distance telephone system, marks an important step in the development of electrical communication. Some little time will be required to educate the people as to its advantages, few being aware of the perfect ease with which a conversation may be carried on with a distant correspondent. The room devoted to this use is 30 x 20 feet in size, on the ground floor, and beautifully lighted. The floor is laid with tiles and the wainscoating is of Italian onyx. The walls are of a buff tint, and the general result is very tasteful, as might be expected from the usual work of this character undertaken by the New York telephone management. The telephone desks are arranged in separate cabinets within which a person may sit comfortably, and privately communicate with various cities in Massachusetts, Connecticut, Rhode Island, or with the most important points in this state, or south to Philadelphia. Messengers are kept at the office to notify persons whose presence at the office has been requested by correspondents in distant places. The company has also placed 100 long-distance transmitters in the "pay" stations in different parts of the city.

A very extensive system of cable railroads is proposed for the city of Newark, N. J., and a company has been formed for their introduction. The recent completion of elevated railways in Brooklyn, and the serious overcrowding of the New York lines makes it important that the cities and towns of neighboring districts in New Jersey should keep up with the times; but it seems strange that in a city so favorably situated as Newark electricity should be entirely ignored. Newark has been within the circle of electric activity since the conception of the Morse tetegraph, and it would appear fitting that if it is to indulge in rapid transit, electricity should be brought into use, especially as its adaptability for such work is no longer experimental, but has proved its merit under the most disadvantageous circumstances.

NEW YORK, June 25, 1888.

. . . . A man who is willing to adopt any good idea, whether it is his own or belongs to some one else, is apt to do better work than with a few ideas of his own, and no room for those of others. —*The Millstone.*

. . . . It is well enough, perhaps, to designate volts obtained by chemical action as equi-volts, but I do not know any reason for it. Really these equi-volts are just plain, ordinary, North American volts.—*Francis B. Crocker.*

PHILADELPHIA.

The Edison Company Busy in the Streets.—Other Electrical Affairs Dull.—The City Enjoined from Laying Conduits on Broad St.—Chief Walker's Views.

WITH the exception of the Edison Electric Light people, who are busily engaged in tearing up the streets in all directions in order to lay their wires on both sides of the Schuylkill river, electrical matters in this vicinity are rather dull.

Chief Walker, of the electrical bureau, was an angry man this morning.

The action of Judge Thayer in granting an injunction restraining the city from laying an electric conduit on Broad street, south of Federal, had completely upset him.

The action of the court he considered unjust, "and I am satisfied it would never have been taken," he added, "had the Judge known the facts. Briefly speaking, the history of the matter is simply this: Arthur McGinn had a contract to repave a portion of South Broad street with Belgian blocks. Before the blocks were laid the electrical bureau—in accordance with an ordinance of councils—opened proposals for the laying of a conduit under Broad street from the City Hall to McKean street, for the accommodation of the police and fire alarm telegraph wires and the city's electric light wires, the idea being to abandon and remove the poles on South Broad street just as soon as the conduit was finished. The supplies for the work were late in reaching us. Nevertheless a sufficient stock came to allow a force of men to begin work on the conduit a week ago. Inasmuch as contractor McGinn had begun at the northern end of his contract and was working southward, and inasmuch as my first object was to lay the conduit without tearing up any of his work, I started my men at Passayunk avenue with instructions to work northward until they reached the new paving. This they did. They took up nothing but old cobblestones, and at the time that the Court, upon McGinn's application, granted the injunction and stopped us, we were not within a square of his paving. The man is either crazy or devilish, for he had no reason whatever to take the course he did. We had no idea of tearing up his work. On the contrary, our main purpose was to avoid that very thing. Had the Court known the facts of the case, I am satisfied it would not have granted the injunction."

McGinn in his application set forth that if the laying of the conduit was allowed to proceed it would spoil his paving and prejudice his claim against the city. Chief Walker states that had he been allowed to proceed he could have laid the conduit without tearing up any of the new paving. As matters are now, about five hundred feet will have to come up.

PHILADELPHIA, June 18, 1888.

BOSTON.

The General Underground Conduit Bill Fails in the Legislature.—Cobb, Pulsifer & Co. Propose to go Ahead Nevertheless, Backed by the Boston Aldermen.—Novel Service of a Telegraph Pole.—Underground Agitation in Rhode Island.—The Snow-Alley Case.—Electric Lights at Malden.—The Fire at the Boston Edison Station; Energetic Action of the Edison Company in Restoring Service.

THE conduit business for Boston, and probably for the other cities in the state, has been clubbed severely, and apparently does not yet know that it is dead. In the legislature the general underground conduit bill was considered at great length on the 22d, 25th and 28th May, failing at passage at last in the senate.

In the senate Mr. Clark pointed out that the promoters of the bill were three men who had been granted exclusive privileges by the Boston board of aldermen, and they appeared before the committee to have this grant legalized. The board of aldermen attempted to exercise a right which they had no right to grant, and the purpose of the petitioners was not to preserve the safety of the citizens of Boston, but to enrich the parties who had exclusive privileges accorded them.

Mr. Clark said further that upon their visit to New York, Brooklyn and Philadelphia the committee were forced to the conclusion that in no city of the United States was there a system which admitted all kinds of wires in the same conduit, and that it was impossible to perfect such a system. The bill before the senate provides that the mayor and aldermen may establish and regulate the laying of these lines, whereas the statutes place such power in the city council, and it is to meet the peculiar state of affairs in the city that this change is made, a majority of the aldermen being favorable to this project, while the common council is opposed to it. This provision was actually put in to give the majority of the aldermen the power which the law as it stands denies them.

The rejection of the bill by the senate ended the conduit matter, so far as the legislature is concerned, for it adjourned without further action upon it; but the "American Conduit Company," have fallen back upon their friends, the eight aldermen of the city of Boston, and Henry E. Cobb, Royal M. Pulsifer and Francis R. Chapman have accepted the franchise granted them, by the board of aldermen for the exclusive right of the streets for twenty years in which to place conduits for carrying telegraph and telephone wires, and have filed a bond in $200,000.

On the 6th inst., at a meeting of the aldermen, an order, authorizing and directing the superintendent of streets to issue a permit to Henry E. Cobb *et al.* to open a certain street was laid over until the next meeting.

The following order was passed:

Ordered, that no more permits be issued for opening streets to construct conduits or lay electric wires without the approval of the board of aldermen. All orders inconsistent with this are hereby revoked.

This order was to shut off the various electric companies who have been and are now putting down conduits in locations previously granted by the aldermen from proceeding any further; meanwhile, the mayor has given orders to the superintendent of streets to allow no digging up of streets, and the police have orders to arrest any person so doing. Our mayor is a large owner of stock in the Brush Electric Light Company doing business in Boston, and has a personal interest against putting electric light wires into a conduit owned by another corporation.

At the board meeting on the 11th inst. the mayor vetoed the above order, in the following communication:—On grounds of illegality,—referring to the opinion of the corporation counsel on which his veto of the ordinance of May 7th was based.

A contemporary says: "The electric wires must never go underground. A telephone pole outside the Riverside base ball grounds converted what would otherwise have been a home run for Manchester into a three-base hit, one day last week." This would appear to be substantial reasoning

Down in Rhode Island the underground wire interest is rising. On the 22d ult., in the Providence common council session the resolution authorizing an application to the general assembly for authority to hire $30,000 to put the city's electric wires underground was indefinitely postponed.

Judge Pitman, in the Superior Court at Dedham, on the 22d ult., decided to grant the motion of Colonel Ingersoll for a new trial in the famous Snow-Alley case, on the ground that the verdict was not in accordance with the law or the weight of the evidence. Colonel Ingersoll is counsel for Mr. Alley. This case has been referred to before in my correspondence, and for several trials has gone in favor of Snow, but Alley is several times a millionaire, and seems to have a way of changing the venue into every circuit.

Malden was lighted wholly by electricity Friday night the 22d ult. for the first time. Nearly all the wires are in position. There are 76 arc and 205 incandescent lights.

At about 12.40 o'clock the morning of the 2d inst. two policemen observed flames shooting up from the rear of the Knickerbocker building on Tremont street, and at once gave alarm 53. It proved that the Edison electric light station on Head place, off Boylston street, was well on fire, and there was every indication that surrounding property was greatly endangered; indeed, when the firemen arrived the rear of the buildings on Tremont street and one on the opposite side of Head place had ignited. There was a hard fight, and the fire was soon under control, but not until the entire upper part of the Edison works was destroyed. The second floor was used as the dynamo room, and here the fire started in an equalizer box. John Gaffney and William Foster were in the room at the time, and so rapid was the spread of the flames that they barely escaped with their lives. N. H. Seavey, the engineer, was in the engine room on the floor below, and also had a narrow escape. In the dynamo room were fourteen dynamos, valued at $2,500 each. In the room beneath were seven engines, one for every two dynamos. In the front of the dynamo room was the office, and beneath was the meter room. The building in the rear contained the boiler rooms, repair shops, &c. The damage to the Edison works, including dynamos, machinery, belts, office and building, will reach about $50,000. The burning of the electric light station cut out this system from the entire city, both the overhead and the underground system being supplied from this station. The Globe Theatre, Hollis Street Theatre, Adams House, Clark's Hotel, Park's Hotel and Young Men's Christian Association buildings are lighted from this source, as are also numerous stores, halls, &c. Several elevators and engines are also stopped by lack of power. The management of the station were equal to the emergency, and immediately cleared the *debris* from the engine and boiler room, telegraphed for new dynamos, and within thirty-six hours were furnishing light again to their subscribers. This was energy and business, and reflects great credit upon those in charge.

BOSTON, June 16th, 1888.

. . . . The electricity is generated from the armature to the field. The current is produced by the velocity of the armature through the magnetic field that produces the current. The strength of the current is 20 amperes (amperes meaning quality), 17 volts (volts indicating the force).—*New Orleans Newspaper.*

CHICAGO.

Electric Service at the Republican Convention.—The Electric Lighting and Telegraphic Arrangements.—Conclusion of Argument in the Cushman Telephone Case.—Practical use of the Graphophone by one of the Court Stenographers.—Electric Club Notes.—Mr. Bliss on Alternating vs. Continuous Currents.—The Aldermen and the Local Press Seeking to Regulate the Chicago Telephone Co.—Damage from Lightning at Milwaukee.—Moderate Reduction of Telephone Rates at Joliet.—Mr. E. M. Barton, President of the Western Electric Co., takes a Vacation in Europe.—The "Rookery" Edison Lighting Plant.—The Sprague Electric Equipment Co.

A SPLENDID exhibition of electric lighting was given in the Auditorium building in which the Republican National Convention was held. About 3,000 incandescent lamps were employed, and the effect was extremely brilliant. The lights were arranged too with an unusual regard for artistic effect and decoration. The main ornamental feature was a shield made by the grouping of 500 incandescent lamps with red, white and blue globes. The effect was striking and brilliant; stars of electric lights were arranged on the ceiling and on the walls, and bunches of three lights were placed under the gallery rails. Current was furnished by two No. 32 Edison dynamos. Two Ide engines furnished the motive power. The telegraph facilities of the convention were such that 100,000 words could be handled hourly. The telegraph companies had about 50 wires run into the auditorium and about the same number of operators were at the desks. They were given plenty of room and were cared for in much better shape than usually at national conventions. The state delegations vied with each other in decorating their headquarters in the Grand Pacific hotel. To the Allison men, however, the honor of bearing off the palm belongs. By grouping a hundred or more incandescent lamps over the door of their headquarters the letters in the name of Iowa's favorite son blazed forth with startling brilliancy.

The most important event in electrical circles during the month was the closing of the suit of the Bell Telephone Co. and the Chicago Telephone Co. against the American Cushman Telephone Co. and others. The arguments which closed this important litigation were heard by Judge Blodgett in the United States Circuit Court. The addresses were made by five counsel, and five days was consumed in the hearing. Nothing particularly new was developed. Counsel on the one hand held that the testimony introduced by the defendants could not for a moment be considered as proof of the validity of the defendants priority of invention. The most that Dr. Cushman could have discovered, it was asserted, was the acoustic telephone. The attorneys for the defendants said this same testimony proved beyond all possibility of a doubt the defendants' claim, unless it was assumed that a score of witnesses had wilfully committed perjury. George L. Roberts, of Boston, made the opening argument for the Bell company. He reviewed the testimony in the case which fills several thousand pages. He instructed the court in all branches of telephony and closed with a statement that Dr. Cushman's action and testimony were characterized by inconsistency. His speech occupied two days. Judge C. D. T. Smith, of Chicago, followed with the opening argument for the defendants. He paid considerable attention to the "talking boxes" which it was alleged Dr. Cushman had used. He asserted with considerable confidence that they could be used practically, and he referred to the evidence of Professor Cross, one of the plaintiffs' experts, in proof of the statement. Benjamin F. Thurston, of Providence, made the next address for the Bell company. James L. High, of Chicago, spoke for the defendants, and Chauncey Smith, of Boston, closed the case for the plaintiff. The last-named gentleman spoke particularly of the failure of Cushman to patent his alleged invention and of the inferences which naturally followed from this neglect. It is hoped that a decision will be handed down not later than the middle of July.

One of the stenographers who reported the arguments brought with him from Washington two graphophones, which he uses continually in his work. The instruments are simple, and they reproduce sound with remarkable fidelity. The tests which were made with them are thought to demonstrate their usefulness satisfactorily.

At the first meeting in June of the Electric Club, George H. Bliss read the seventh paper on the "Alternating *vs.* the Continuous Current." He viewed the subject almost exclusively from a commercial point of view. His point in brief was this: The continuous current, by its success, had demonstrated its usefulness and its safety. It had brought in dividends to stockholders, and its history was such that it had created a presumption in its favor. On the advocates of the alternating system rested the burden of proof. On them devolved the duty of proving the superiority of their method of central station distribution. This proof Mr Bliss held had not yet been forthcoming; and it is safe to assert from the general tenor of his paper that he does not expect to find evidence which will be conclusive to him.

If they can find authority for doing so, the Chicago aldermen propose to follow the example of the St. Louis city council and make war on the Chicago Telephone company. The Chicago council is almost to a man opposed to the company and would enjoy nothing better than to reduce the telephone rates. The legal department of the city is engaged in consulting authorities to ascertain if the council has a right to adjust rates—a right hitherto supposed to be vested in the legislature. The local press is advocating the adoption of an ordinance charging the telephone company a license fee of $10 per year for each instrument. That would give the city a revenue of $40,000. It is said that the company is willing to pay a licensé fee of $5 for each telephone.

Milwaukee experienced a severe storm on June 14th. The lightning struck the telephone wires and burned out the Michigan street cable. The service was temporarily disabled. The police and fire alarm systems also suffered from the same cause.

Joliet has made a decided innovation. The telephone company has reduced the rates in that city to $54 for business houses and $36 for residences. The change entirely removes the dissatisfaction which has heretofore existed concerning charges.

Mr. E. M. Barton, president of the Western Electric Co., has left Chicago for an absence of some months in Europe.

The Edison plant in the Rookery, Chicago, is one of the largest isolated plants in the country. It consists of 4,500 lights. The current is furnished by four dynamos. The Rookery is the finest office building in Chicago, and the owners claim it is the most elegant in the world.

The Sprague Electrical Equipment Co., of Chicago, has been incorporated. The capital stock is $50,000. The company proposes to engage in construction work.

CHICAGO, June 22, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall street, New York city.*

GRAVITY BATTERY vs. DYNAMOS.

[94].—In reading Mr. Francis B. Crocker's interesting paper on "The Possibilities and Limitations of Chemical Generators of Electricity" appearing in the June number of the ELECTRICAL ENGINEER, I was almost lead into an error by the statements in the fifth paragraph on page 252, comparing gravity batteries to a dynamo. I do not wish to appear to correct Mr. Crocker, but only to keep some other readers of the article in question from an error into which I nearly fell. At first I understood that 1,500 gravity cells would give a useful output equal to one electrical horse-power; this is not meant, as in the case supposed there could be no external circuit and consequently all the work would be done in the battery itself. As I have never met with any statement as to the number of cells necessary to give a definite current with a given fall of potential, it has seemed to me interesting to find formulæ for the number of cells of any battery needful to supply any power. Let $C =$ current required; $E =$ E. M. F. at terminals; $e =$ E. M. F. of cell; $r =$ its resistance; $m =$ number of cells in parallel and $n =$ the same in series. Taking it for granted that the resistances within and without the battery should be equal, we have one mth of $n\,r$, or

$$\frac{n\,r}{m} = \frac{E}{C} \therefore m = n\frac{C\,r}{E} \text{ or substituting for } n \text{ its value } n = \frac{2\,E}{e}$$

$$\text{(because } E = \tfrac{1}{2}\,n\,e\text{)} \quad m = \frac{2\,C\,r}{e} \qquad (1)$$

$$\text{Now } C = \frac{n\,e}{\frac{n\,r}{m} + \frac{E}{C}} \text{ or } n = \frac{E\,m}{m\,e - C\,r} \qquad (2)$$

Suppose 10 lamps of 100 volts and .75 ampere are to be fed by gravity batteries whose constants are as given by Mr. Crocker, 1 volt and 2 amperes, then by (1) we have $m = 30$ and by (2) $n = 200$ or $m\,n = 6{,}000$. That is, it would require 6,000 ordinary gravity cells to give one electrical horse-power to an external circuit. Also a current of one ampere and 750 volts, and of 750 amperes and one volt, would require the same number differently arranged.

Of course the above example shows that it would be ridiculous to use gravity batteries for such use; but as the formulæ are general they can be applied to any cells.

Yours truly, DS.

WELDING RAILS BY ELECTRICTIY.

[95.] In the correspondents' column of the last issue of the ELECTRICAL ENGINEER, Mr. Otis K. Stuart takes advantage of an extract on the above subject that appeared in the May number, to criticise my method of electrically welding and tempering metals as applied to the construction of railway lines. In this article he attempts to show, among other things, first, that the welding of steel rails in the manner proposed by me is practically impossible, and secondly, that the difficulties in the way of successfully operating a road provided with continuous rail sections 1,000 feet in length, such as those arising from expansion and contraction, etc., are such as to render the "scheme" entirely impracticable.

Before replying to this criticism in detail, it will be necessary for me to digress somewhat in order that your readers may better understand the situation. It will be evident from a perusal of his letter that Mr. Stuart imagines that, because he fails to understand a new process, or because the description thereof is not sufficiently explicit to enable him to comprehend it, the inventor of the process is either a crank or is totally unacquainted with the subject upon which his process is based. In contradistinction to this assumed lack of knowledge on the part of the inventor, Mr. Stuart himself, undertakes to speak in an authoritative manner not only upon the subject of electric welding, but, to judge from his closing paragraph, upon electrical matters in general. In addition, he would seem to be gifted with the rare faculty of distinguishing between what invention will and what will not be a success, without exercising the preliminary formality of inquiring into the features or details of the subject upon which he so freely expresses his opinion. Had Mr. Stuart taken the pains to acquaint himself with the essential details of the system that he is apparently so anxious to condemn, instead of jumping at conclusions from a mere newspaper extract, he would at once have become aware that his alleged "difficulties" had no foundation in fact, or were provided for and successfully overcome long before his effort to formulate them was written.

To those who are aware of Mr. Stuart's connection with the Thomson Electric Welding Co. it may not be a matter of much surprise that he should endeavor to attack a rival system, especially when this system contains features that are absolutely essential to the successful operation and the commercial development of the system with which he is identified. Personally, however, I was not only much amused at the nature of the objections raised in the letter under notice, but considerably surprised to find that they emanated from Mr. Stuart.

The source of my surprise may be understood from the fact that about one month *after* the issue of my patent (No. 370,282, granted September 20th, 1887), for this process of welding and laying railway tracks and other continuous sections, and for the method of electric welding and tempering involved therein, an application for letters patent was filed by Professor Elihu Thomson, to which were appended *exact duplicates* of several of my broad method claims, and with this application was filed an affidavit and petition signed by Professor Thomson, praying that such application be put into interference with my patent. This interference has since been declared, and the contest for priority of invention on the methods involved is now pending between us.

In view of the above facts, I cannot but conclude that Mr. Stuart, in his ardor and zeal to advance the interest of Professor Thomson, has, without consulting with his superior, heedlessly rushed into print to criticise on general principles a system with the details of which he is entirely unacquainted. I believe I am correct in drawing this inference, since it is apparent that Professor Thomson would not be so injudicious as to attempt to prove the impracticability of a "scheme" which he is striving his utmost to obtain possession of, unless, indeed, he has already arrived at the conclusion that there is nothing to be gained by him in continuing the contest now pending before the Examiner of Interferences in the Patent Office.

Having thus presented the facts of the situation to the reader, I will now consider the objections advanced by Mr. Stuart.

Mr. Stuart's first objection is that the joints and adjacent parts of the rail could not be tempered equally with the other parts of the track. This may be true with regard to the peculiar tempering process or processes, if any, heretofore practiced by him. If Mr. Stuart will glance at a copy of the patent above referred to, describing this method of welding and laying railway tracks, he will find, among other things, the two following claims, which not only describe the method by which a uniform temper *is* produced, but which cover *broadly* the art of electric welding in which the current strength is gradually increased to prevent burning the metal or permanently destroying its tempering qualities at the joint, to wit:—

"2. The herein described method of welding together two metals of hardened or tempered structure without destroying their respective retempering properties at the point of union, which consists in passing an electric current of heavy heating effect through the ends in contact and gradually increasing the current strength until they reach a fusing temperature, as described."

"4. The herein described method of effecting a hardened or tempered junction between two metals of similar density and like cross-section, which consists, first, in welding the ends in contact by the passage of an electric current or currents therethrough, and secondly, *in reheating the said joint* and applying a suitable tempering compound when the joint has reached the desired degree of heat for tempering."

A question that seems to present insurmountable difficulties to the mind of my esteemed critic, is that of providing for the "enormous amount of expansion and contraction in rail lengths of 1,000 feet." If the solution of this problem were entrusted to the hands of Mr. Stuart, there would, indeed, be reason to fear for the result. Fortunately, however, for the safety of the future traveling public, I am able to state that this question has been solved in such a manner that not only can none of the disastrous results predicted by Mr. Stuart possibly occur, but a railway of this description is far more safe, economical in construction and maintenance, and more conducive to speed and the pleasures of travel than the ordinary railway lines with their innumerable joints, fish plates, nut locks, etc., can ever be made, to say nothing of the immense saving in cost of repairs to rolling stock and road bed that the absence of rail joints will effect.

The co-efficient of expansion per degree Fahr., according to the best authority, is, for steel, .0000066. A steel rail 1,000 feet in length would, therefore, expand or contract .792 inch for each 10 degrees variation in temperature, instead of 1.5 inches as stated by Mr. Stuart. Allowing a maximum range of temperature of 150 degrees Fahr., we have a total expansion and contraction of 11.88 inches, or something less than one foot, to provide for in our expansion joints in a length of 1,000 feet. Now, inasmuch as each thousand foot length is rigidly secured at its centre, it can only expand toward or contract from both ends, and, therefore, the maximum movement *at its extremities* within the entire range of temperature above stated can never exceed six inches. It must, moreover, be borne in mind that there will be required a variation in temperature of 25 degrees to produce a movement of *one inch* at the extremities of each rail section, and that this is above the usual

Fig. 1.

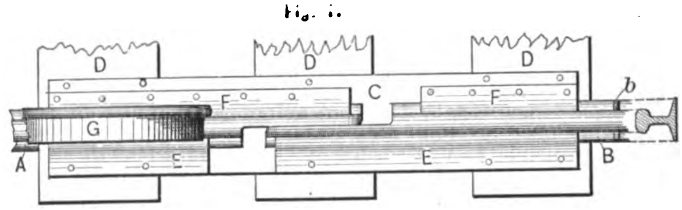


Fig. 3.

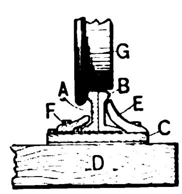


Fig. 2.

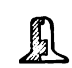


Fig. 4.

maximum variation in temperature within the limits of a day of 24 hours. This small amount of to-and-fro movement or "creep" in each rail section daily, assisted as it is by the passage of trains over the road, is scarcely perceptible, and even on roads where the rails are secured by the ordinary rail spikes, can be allowed without detriment. Preferably, however, I employ a slightly modified form of spike or rail fastening that is equally simple and permits of free longitudinal motion, while at the same time it holds the rail with the utmost security against lateral displacement. It is scarcely necessary to add that the "buckling," "ruptures" and other difficulties prophesied by Mr. Stuart, have absolutely no material existence in this connection, nor can such phenomena find place anywhere except perhaps, in his own imagination.

The variation in the length of each rail section is compensated for by divided expansion joints so arranged that there is no interruption or break in the bearing surface of the rails throughout the entire track, the latter being practically continuous and entirely free from the objections incident to the use of the ordinary rail joints. These expansion joints are located at intervals of 1,000 feet on substantially straight and level portions of the road (or any other distance apart that may be desirable), and in the case of curves, are located on the straight portions of the track a short distance before and beyond the curve respectively, the comparatively short curved section being rigidly secured at its centre and expanding in both directions in the same manner as the straight sections.

The construction of the expansion joints will be understood from the annexed plan and elevation, figures 1 and 2. A, B, represent respectively the divided extremity of each rail section, as they are held in alignment upon a bed plate, C, secured to the

cross-ties, D. The bed-plate, C, is provided with fixed guides, EE, and adjustable guides, FF, between which the rails are free to move in a longitudinal direction. The end pieces, A, B, of each section are preferably made of aluminum steel, to increase their strength; and each half of the divided joint is tested to support without deflection a load several times that of the greatest weight they are ever called upon to bear in practice. The extreme ends of the rails are slightly inclined, and as the tread of the wheels is broader than the head of the rail, and the whole arrangement supported upon a solid unyielding plate, the transit from one rail section to the next is made without the slightest perceptible shock or jar.

It should be further stated that in forming a rail section by the process of electrically welding the ordinary rail lengths together, the joint produced between two successive lengths is preferably provided with a rib between the head and flange, as shown in figure 3, and at *b* in figure 1. This insures a greater degree of strength at the juncture, and renders the entire roadbed smooth, safe and substantial. A modified form of divided joint is illustrated in figure 4.

As to Mr. Stuart's remaining criticisms, I can only repeat that it would speak much better for Mr. Stuart's "familiarity" with the subject if he but took the pains to find out what has already been done in this field before venturing his predictions as to what has *not* been accomplished. A man is not likely to build himself a house without providing some means of getting into and out of the same, nor am I likely to build a line of railway without providing means for renewing worn portions of the track when necessary. This, I may state for the satisfaction of Mr. Stuart, has been accomplished in such a way as to permit of rapidly cutting out the condemned portion and welding on a new length *in situ*, without loosening or disturbing the rails on either side and without interfering with traffic, by means of a special process and mechanism devised for this purpose. It may be stated, however, that owing to the absence of the severe pounding or hammering action that occurs at the joints of all ordinary roads as at present constructed, the tendency to wear in the continuous rails will not only be uniform, but the life of the rails will, in all probability, be three or four times what it is at present. This will be appreciated when it is understood that there are generally 176 interrupted joints to the mile for each rail, as against five divided joints in this system.

In conclusion, I wish to state that before very long Mr. Stuart will have the opportunity of seeing a line of railway constructed upon this principle and in successful operation, and will then have a chance to reflect that it is his theories, and not the "plans" to which they are directed, that have proven themselves commercially impracticable and visionary.

Very respectfully

ELIAS E. RIES.

430 So. Broadway, Baltimore, Md., June, 1888.

LITERATURE.

REVIEWS.

Dynamo Tenders Hand Book: BY F. B. BADT. Chicago: Western Electrician Co.; 100 pages, 70 illustrations, flexible cloth. Price, $1.00.

THIS manual—now some three months before the interested public—has, we understand, been well received in electric light and power circles.

In his preface Mr. Badt says he "has striven to lay down, as the results of an extended experience, general rules for the care and operation of electric light installations, and discarding entirely the use of technical phraseology and scientific terms and formulæ, has endeavored to confine his use of words to those very plain, simple and elementary in character."

A book of this kind was much needed, inasmuch as the rapid growth of electric lighting as an industry has necessasily called into its service large numbers of employés having no previous acquaintance with electrical machinery of any kind. The many volumes already existing that treat of electric lighting or other applications of dynamic electricity, scarcely touch the line of instruction which makes up the greater part of Mr. Badt's handy volume. Lampmen, linemen and all other employés of electric light stations, as well as dynamo tenders, will find much useful information in small compass in this little book, which is small enough for the coat pocket. The directions given are plain, simple, even obvious, one would think to any fairly intelligent man in electric lighting service; but so long as plain and obvious things escape ordinary observation, as they usually seem to, somebody must call attention to them. Such work is particularly important, when ignorance or failure to recognize and observe ordinary precautions endangers life and property, as it does in electric service.

American Street Railways, their Construction, Equipment and Maintenance: BY AUGUSTUS W. WRIGHT. Consulting Engineer, Member A. S. C. E., etc. Chicago: Rand, McNally & Co., 1888.

MR. Wright's high reputation as a street railway engineer would of itself be a sufficient guarantee of the quality of any work on the subject of the volume under notice from his pen. The general public is very apt to regard horse-railroads as in the category of very simple undertakings. Daily familiarity with them and use of them obscures from general observation the perplexing and rather difficult engineering and administrative problems involved in their commodious and successful operation. General readers would doubtless be surprised by a glance through Mr. Wright's book, to note the large number of technical, economic, and administrative questions that demand careful consideration by the street railway engineer. Under the several chapter headings—Construction—Paving—Track Cleaning—Equipment—Buildings for Street Railways and Management of Street Railways,—Mr. Wright treats the subject comprehensively and with fullness of detail. The treatise is practically confined to horse-railroads. To this, of course, no objection can be made, for notwithstanding the introduction of the cable and the electric motor, horses are still the general reliance for motive power. But these new methods of traction are coming to the front so rapidly for street traffic, that a treatise on American Street Railways, dated 1888, might fairly be expected to have something more to say about them than the bare allusion in Mr. Wright's appendix.

The publishers have done more than well in the convenient size and shape of the book, its handsome paper and type and its substantial and tasteful binding. The volume is well illustrated. It is a pity to find any fault with the make-up of a book so convenient and pretty, but its convenience would have been enhanced by running chapter-headings in place of the general title, on every alternate page.

RECENT PUBLICATIONS

American Patent Cases. A collection of patent cases criticised, explained, overruled, or otherwise limited by subsequent decisions of the Federal Courts, giving a short statement of the point criticised. By Simon G. Croswell, editor of the fourteenth edition of "Greenleaf on Evidence." 12mo., sheep. 286 pages. Price $3.00 net. Boston, Little, Brown & Co., publishers.

Revista do Club de Engenharia, Anno 1—Vols. iv., v. and vi.—Abril, Maio, Junho, 1887. Rio de Janeiro.

CATALOGUES AND PAMPHLETS RECEIVED.

Under the title Elettricita Teorico-Pratica we have received the catalogue and price list of the Società Elettrica Industriale Franco-Italiana of Milan, a handsome pamphlet of 128 pages, very copiously illustrated and fully indexed. The lists and illustrations comprise nearly everything pertaining to modern applications of electricity, from school apparatus and toys to dynamos and transformers.

The Woodhouse & Rawson Electric Supply Co. of Great Britain (Limited), of London, England, issue a catalogue of domestic electrical supplies of a more than usually elaborate and comprehensive character. It is not unlikely that many American manufacturers and dealers would find some objects of interest in this well illustrated list. We are used to considering ourselves ahead of all the rest of the world in electrical applications as well as in most other things. It is well now and then to look about a bit and see what others are doing. The catalogue of the Woodhouse & Rawson company indicates that domestic electric service is both elaborate and extensive in Great Britain.

The Writing Telegraph, that very interesting recent development of telegraphy, is quite fully described and illustrated in a small pamphlet published a short time ago by the Writing Telegraph Company of New York. Many of our readers will remember seeing the system of Mr. Robertson in operation at the electrical exhibition of the American Institute fair last autumn. The general office of the company is at 57 Murray street, New York.

The Bentley-Knight Electric Railway Co.'s latest circular announces the claim of that company to "control all practical methods of operating electrically equipped cars by means of conductors contained in and protected by subsurface conduits." Very handsome illustrations are given of their fully equipped trucks, of cars, and of some details of construction. Estimates are given of construction and equipment, and of running expenses for a double track, five mile, 40 car road for horse, electric and cable traction. The comparative figures are much to the advantage of electricity. The Bentley-Knight company were early in the field, and have worked out a full system of electric street railway.

Advertising circulars and pamphlets are more and more enlisting the services of artistic designers and printers, till they vie with Christmas and Easter cards in beauty and elegance.

We have seldom seen a handsomer circular than that recently issued by the Ansonia Brass and Copper Company, containing testimonials to the good qualities of the Cowles' patented fire proof and weather proof line wire. The Ansonia Company was one of the first of the large brass and copper companies to realize the prospective large consumption of insulated wires, and to prepare themselves to meet it directly, by establishing a plant of insulating machinery.

The Effect of Magnetism in Watches.—How to prevent it—a pamphlet of 14 pages, published by the Geneva Non-Magnetic Watch Co., New York, consists of a paper by Mr. C. C. Haskins, of Chicago, prepared for the convention of the Brotherhood of Locomotive Engineers at Chicago, in October, 1887. The timeliness of the subject is sufficiently evident from the very considerable attention it has received in the discussions of electrical societies and in technical journals. Mr. Haskins treats the topic in his usual practical common-sense way, and his essay will be found of interest to all who are anxious about their time pieces.

The Electro-Automatic Transit Company, Baltimore, Md., issue a prospectus setting forth a scheme of electric telpherage, giving pictorial illustrations of tracks and carriages, and some estimates of construction and operation. The company claims to "control the patents, under this system, for the United

States and all the principal countries of the world." "It is now ready to receive overtures or propositions for the formation of companies and the building of roads under said patents." It is not "said," however, what patents are controlled. The circular is fortified and embellished by the following quotations:

"'Tis not in mortals to *demand* success,
But we'll do more * * * We'll *deserve* it," and

"There are more things in heaven and earth * * * than are dreamed of in your philosophy."

The first of these is certainly most praiseworthy.

ELECTRICAL NEWS AND NOTES.

THE COURT OF PATENT APPEALS BILL.

Below we print the bill proposed by the National Electric Light Association to create a court of patent appeals, as amended by Mr. Justice Bradley and Mr. Justice Miller, both of whom have given it careful attention; also letters approving the bill, from the late Chief Justice Waite, Justices Bradley and Miller, the Commissioner of Patents and the Patent Bar Association of Washington. In the House of Representatives the bill has been read twice, referred to the Judiciary Committee and ordered printed.

A BILL

To establish a Court of Patent Appeals of the United States.

BE IT ENACTED *by the Senate and House of Representatives in Congress assembled:*

SEC. 1. There shall be a Court of Patent Appeals of the United States, which shall consist of a Chief Justice and four Associate Justices, who shall be appointed by the President, by and with the advice and consent of the Senate, and who shall hold office during good behavior. Any three of said Justices shall constitute a quorum.

SEC. 2. The Associate Justices shall take precedence according to the dates of their commission, or when the date of the commission of two or more of them is the same, according to their ages.

SEC. 3. In case of a vacancy in the office of Chief Justice, or of his inability to perform the duties and powers of his office, they shall devolve upon the Associate Justice, who is first in precedent, until such disability is removed, or another Chief Justice is appointed and duly qualified. This provision shall apply to every Associate Justice who succeeds to the office of Chief Justice.

SEC. 4. The Justices of the Court of Patent Appeals shall receive the sum of eight thousand dollars each per annum, to be paid monthly.

SEC. 5. The Court of Patent Appeals shall have power to appoint a Clerk and a Marshal for said Court, and a Reporter of its decisions.

SEC. 6. One or more deputies to the Clerk of the Court of Patent Appeals may be appointed by the Court on application of the Clerk, and may be removed at the pleasure of the Court. In the case of the death of the Clerk, his deputy or deputies, shall, unless removed, continue in office and perform the duties of the Clerk in his name until a clerk is appointed and qualified; and for the default or misfeasance in office of any such deputy, whether in the life-time of the Clerk or after his death, the Clerk and his estate and the sureties on his official bonds shall be liable, and his executors and administrators shall have such remedy for such default or misfeasance committed after his death, as the Clerk would be entitled to if the same had occurred during his life-time. The fees of the Clerk shall be the same as those of the Clerk of the Supreme Court for like services, but shall not exceed six thousand dollars per annum; the residue to be accounted for to the treasury of the United States. The salaries of the deputy clerks shall be fixed by the Court in no case to exceed twenty-four hundred dollars per annum.

SEC. 7. The Marshal shall be entitled to receive a salary at the rate of two thousand dollars a year. He shall attend the Court at its sessions, shall serve and execute all process and orders issuing from it, or made by the Chief Justice or an Associate Justice in pursuance of law, and shall take charge of all the property of the United States used by the Court or its members. With the approval of the Chief Justice he may appoint assistants and messengers to attend the Court, with the compensation allowed to officers of the House of Representatives of similar grade.

SEC. 8. The Reporter shall cause the decisions of the Court of Patent Appeals, made during his office to be printed and published within six months after they are made, and within the same time, shall deliver three hundred copies of the volumes of said report to the Attorney-General. And he shall, in any year when he is so directed by the Court, cause to be printed and published a second volume of said decisions, of which he shall deliver in like manner and time, three hundred copies.

SEC. 9. The Reporter shall be entitled to receive from the treasury an annual salary of twenty-five hundred dollars, when his report of said decisions constitutes one volume, and an additional sum of fifteen hundred dollars when, by direction of the Court, he causes to be printed and published in any year a second volume. But said salary and compensation respectively shall be paid only when he causes such decisions to be printed, published and delivered within the time and in the manner prescribed by law, and upon the conditions that the volumes of said report shall be sold by him to the public for a price not exceeding four dollars a volume.

SEC. 10. The three hundred copies of the reports of the Court of Patent Appeals shall be distributed by the Attorney-General as follows: To the Commissioner of Patents forty copies, and the balance as provided in the section 683 of the Revised Statutes for the distribution of the Supreme Court reports.

SEC. 11. The Court of Patent Appeals shall hold at the seat of government one term annually, commencing on the second Monday in October, and such adjourned or special term as it may find necessary for the despatch of business.

SEC. 12. If at any session of the Court of Patent Appeals a quorum does not attend on the day appointed for holding it, the Justices who do attend may adjourn the Court from day to day for twenty days after said appointed time, unless there be sooner a quorum. If a quorum does not attend within said twenty days, the business of the Court shall be continued over until the next appointed session; and if during a term, after a quorum has assembled, less than that number attend on any day, the Justices attending may adjourn the Court from day to day until there is a quorum, or may adjourn without day.

SEC. 13. The Justices attending at any term when less than a quorum is present, may, within twenty days mentioned in the preceding section, make all necessary orders touching any suit, proceeding or process, depending in or returned to the Court, preparatory to the hearing, trial or decision thereof.

SEC. 14. The Court of Patent Appeals of the United States shall have appellate jurisdiction in the cases hereafter specially provided for without regard to the sum in controversy.

1. "From the Courts of the United States having original jurisdiction of cases touching patents, copyrights, trade-marks and labels, in all cases involving these subjects."

2. From the Commissioner of Patents in all cases touching the patentability of inventions, priority of invention among several claimants for patent upon the same invention, and in all cases of re-issue and the judicial practice of the Patent Office, also all cases touching the registration of trade marks or labels and the rights of conflicting claimants therefor.

SEC. 15. From and after the passage of this Act, there shall be no appeal from the Circuit Courts of the United States or any territorial or district Court or Court of the District of Columbia, in cases touching patents, trade-marks, copyrights or labels, to the Supreme Court of the United States directly, but all such cases formerly appealable to the Supreme Court shall be heard on appeal by the Court of Patent Appeals.

SEC. 16. There shall be a right of Appeal from the Court of Patent Appeals to the Supreme Court of the United States in all cases regardless of the amount in controversy; subject to the same regulations, however, as now exist with regard to appeals to the Supreme Court in causes of Admiralty and Maritime jurisdiction, and to such further regulations as the Supreme Court of the United States may make.

SEC. 17. All cases touching patents, trade-marks, copyrights or labels, now pending before the Supreme Court of the United States awaiting trial shall be transferred to and heard by the Court of Patent Appeals.

SEC. 18. When any Judge of the Court of Patent Appeals resigns his office after having held his commission as such, at least ten years, or who has held his commission as such for not less than five years, having previously held a commission as a Judge of Circuit or District Court of the United States for a period sufficiently long to make up ten years' service as a Judge of a United States Court, and having attained the age of seventy years, he shall, during the residue of his natural life, receive the same salary which was by law payable to him at the time of his resignation.

SEC. 19. Section four thousand nine hundred and eleven of the Revised Statutes shall be, and hereby is amended so as to read as follows: If such party is dissatisfied with the decision of the Commission he may appeal to the Court of Patent Appeals of the United States.

SEC. 20. Section four thousand nine hundred and twelve of the Revised Statutes shall be, and hereby is amended so as to read as follows: When an appeal is taken to the Court of Patent Appeals the appellatee shall give notice thereof to the Commissioner, and file in the Patent Office, within such time as the Commissioner shall appoint, his reasons of appeal, specifically set forth in writing.

SEC. 21. That section forty-nine hundred and fifteen of the Revised Statutes of the United States is hereby repealed.

SEC. 22. That section seven hundred and eighty of the Revised Statutes relating to the District of Columbia is hereby repealed.

SEC. 23. All Acts or parts of Acts inconsistent with the provisions of this Act are hereby amended so as to be consistent therewith.

Approval of Justices of the Supreme Court of the United States.

Supreme Court of the United States,
Washington, May 25th, 1888.

Hon. George Ticknor Curtis,
My Dear Sir :

It gives me pleasure to say, that, after going over the Bill of the H. of R. No. 9084, to establish a Court of Patent Appeals, and making a few suggestions which you accepted, I approve of the Bill entirely. It will do much to relieve the overburdened docket of our Supreme Court in a direction where it can best be done.

Although the Bill has been submitted to no distinct vote of the members of the Court, it has been considered by them all, and I feel sure that I express their concurrent opinion when I say, that they all desire the passage of the Bill, and will be much gratified if it shall become a law.

I am very truly yours, SAM'L F. MILLER.

Supreme Court of the United States.

Washington, April 9, 1888.

Arthur Steuart, Esq.,
Dear Sir :

Your Bill (H. R. 9084) would make a great improvement in this department of Judicial procedure.

Very truly yours, JOSEPH P. BRADLEY.

Letter from the late Chief Justice Waite to Mr. Geo. Ticknor Curtis.

Washington, March 16, 1888.

My Dear Mr. Curtis :

I have read carefully your letter to Mr. Gorman, a copy of which some one has been good enough to send me, and agree with you cordially in all your suggestions, but especially that which relates to the finding of facts by the Court of Patent Appeals. There is no more reason why the facts should come before us in this class of cases after the trials below, than there is in cases of Admiralty.

Sincerely yours, M. R. WAITE.

Opinion of the Commissioner of Patents.

U. S. Patent Office,
Washington, D. C., May 26th, 1888.

Arthur Steuart, Esq.,
Baltimore, Md.,
Dear Sir ,

I have considered the Bill, H. R. 9084, with amendments suggested before sub-committee of Judiciary Committee of the House, and am convinced that it meets the urgent requirements of the present situation. It will tend directly and immediately to relieve the Supreme Court of its enormously overgrown docket, and to abolish the delays in the administration of law which now almost amount to a denial of justice. The patent laws in their application must be applied by expert tribunals. The Patent Office is an Expert in the Arts. It is required to be such, not only by the nature of its duties, but by the principles of its organization. It is impossible that judicial tribunals can properly and safely revise and review its work, and adjudge the rights of the public and of individuals arising from its operations, without possessing an element of the knowledge and familiarity of the expert that lies at the foundation of the whole system.

I sincerely trust Congress can be induced to give the subject the consideration it is worthy of.

Yours very truly, BENTON J. HALL.
Commissioner of Patents.

Opinion of the Bar.

Washington, D. C., May 22, 1888.

The Patent Bar Association of the District of Columbia is strongly in favor of a Court of Patent Appeals, such as is proposed by Bill H. R. 9084. We are clearly of the opinion that such a Court would be of vast importance.

First: By securing a far more uniform practice in the granting of patents, by which there would be less invalid patents granted, and the capital invested in patents and business enterprises based upon patents would be rendered more secure.

Second : It would lessen litigation, and what is equally, if not more important, it would enable patent cases to be decided in much less time.

Third : It would relieve the Supreme Court, for very few cases would ever go beyond the proposed Court.

Fourth : It would put an end to the conflicting decisions which is one of the great troubles of the day.

W. C. DODGE,
President Patent Bar Association.

THE WESTERN ELECTRIC COMPANY'S SINGLE CORD MULTIPLE SWITCH-BOARD FOR TELEPHONE EXCHANGES.

One of the most radical improvements recently made in the multiple switch-board for telephone exchanges is the so-called "single cord multiple."

The first board of this kind for practical use was installed some six months ago at the Eighth and Freeman street exchange of the City and Suburban Telegraph Association of Cincinnati. The board was arranged for 800 lines, and at present consists of five sections with 100 lines to each section. A board similar to this has also been in use a short time at Providence, R. I, and new ones are being installed at Brooklyn and Buffalo.

The advantage gained by the single cord system is the immediate answer which is given to the subscriber on receipt of his call. The operator picks up the plug to which the line of the calling subscriber is connected, and the head telephone is then in circuit with the subscriber. The operator seems to know which plug to reach for on the fall of a drop without any hesitation, just as a typewriter operator or piano player reaches for the right key. Tests were recently made with a stop watch, giving the time to fifths of a second.

These tests show the time from the fall of the annunciator drop to taking up the plug as one second; the getting of the number wanted from the subscriber who calls, when the subscriber gives the number promptly, as one second ; testing and inserting the plug as one second ; ringing and pushing in the key to disconnect the operator's telephone and restoring the drop as one and one-fifth seconds, making a total of four and one-fifth seconds.

The time required for disconnection, from the fall of a drop to getting the head telephone in circuit for listening is one second, and for taking off the connection is one and one-fifth seconds, making a total, for a connection and disconnection, of six and two-fifth seconds. This was found to be an average of a great many calls. In some cases the operators do better.

The quickness with which the operators make the connections and disconnections keeps them ahead of their work, so there is but little trouble from several calls coming in in quick succession.

If the subscriber would make no delay in announcing the number wanted, and if there were lines enough for each section to give the operators all the work they could do, by working with both hands and letting the connections lap over each other, they could make an easy average of six seconds for a complete connection and disconnection, which would be ten for a minute and six hundred for an hour, which is nearly three times the maximum work of an operator in any exchange where a count has been made.

The board has given excellent satisfaction. The superintendent of exchanges, of Cincinnati, writes :

"In operating the single cord multiple, the advantages gained over the double cord are that it requires only half the motions to complete connections between subscribers. To illustrate : On the single cord ten motions of the arm are necessary to answer, connect and disconnect ; on the double cord it takes eighteen. In detail, they are, single cord to answer, two motions ; double cord, four ; single cord, to connect, four motions ; double cord, seven; single cord, to disconnect, four motions ; double cord, seven.

"Our experience with the switch-board has been satisfactory, as it lessens the time and labor for each connection nearly one-half."

THE BOSTON ELECTRIC CLUB'S ANNIVERSARY.

On Thursday, June 21, the Boston Electric Club celebrated its first anniversary. The day was made the occasion for entertainment and hospitality in the true whole-souled Boston manner. The doors of the pleasant apartments of the club were thrown open at one o'clock for the reception of the members and invited guests, and when a large number had gathered, President P. H. Alexander made an address of welcome. He briefly described the growth of the club from a membership of 19 at its formation a year ago to 250 at the present time, and pointed out the advantages of the organization in bringing into fraternal relations the representatives of competing electric companies with the resulting gain to common interests attendant upon an interchange of ideas and experiences. Mr. Alexander hoped that the social and educational features of the club would attract new members, and sustain the interest and secure the attendance and hearty co-operation of the present membership during the ensuing year.

Mr. T. A. Edison and Mr. Gilliland were expected to be present and to exhibit the phonograph. A letter of regret was received from Mr. Edison, in which he stated that the phonograph was not yet perfected, and that when it should be first exhibited publicly it would be at the Boston Electric Club.

During the afternoon reception, a light lunch was spread in the parlors. Several pleasant hours were spent in social intercourse, greatly promoted by the toothsome luncheon and fraternal cigars till 4;30 o'clock, when the members and guests took the steamer "Nantucket" for Nantasket to enjoy a dinner at the Rockland house. About 150 gentlemen sat down to meat, drink and smoke, after which carnal but innocent pleasure the flow of talk began.

After brief remarks by the president, Mr. Alexander, addresses were made by Mr. Allan V. Garratt, Mr. Frank Ridlon, Mr. T Commerford Martin, Mr. C. W. Price, Mr. Prescott of the Boston *Globe*, Mr. A. J. De Camp, Col. Ransom, and others. Letters of regret were read from Moses G. Farmer, Thos. A. Edison, and others, who were unable to be present. At 9.30 o'clock the company took train for Boston, well pleased with themselves, and better pleased with the Boston Electric Club.

MOTORS FOR SMALL POWERS IN CHICAGO.

In the issue of the *Western Electrician* of February 4th, the fact was chronicled that the first small motor for power purposes run from an arc circuit of the Chicago Arc Light and Power Company, was in operation in Chicago, and the opinion was expressed that the prospects for an extensive use of motors were very bright. Last week saw an order recorded for the twenty-eighth Baxter motor for use in this city. The Chicago office of the Baxter Electric Manufacturing and Motor Company, W. W. Munro, manager, was opened for business ten weeks ago, and the motors ordered of them have all been ordered during that time.

In Chicago, motors are used in blank book, clothing, cloak, dress trimming, electric appliance, exhaust fan, hat and cap,

leather, truss, shirt, vest, and ventilator manufactories, book binderies, to run coffee mills, exhaust fans, lithographing and printing establishments, by publishers, lapidaries and opticians.

In company with Frank L. Perry, electrician of the western department of this company, who installed all the motors in Chicago, a *Western Electrician* representative made a tour of investigation. The first motor seen was in the shop of Chas. Essig, a lapidary on State street, who was found busily grinding stones of all manner of description. Mr. Essig is in a building in which there is no power, and is located on the top floor. He is eminently well pleased with the operation of his half horse-power motor. A printing establishment run by a 2 h. p. motor was next visited. Several small presses and a paper cutter were in operation, and here, too, great satisfaction was expressed with the operation of the motor.

In the shop of the Western Leather Manufacturing Co. there was a 1 h. p. motor operating three sewing machines, a strap puncher, two wax thread machines and a harness-creasing machine. The foreman and the girls, who had formerly run the machines by foot power, were equally loud in their expressions of delight—the foreman because on certain classes of work at least two-thirds more was accomplished in a day's time than under the old method, and the girls because they could accomplish so much more work at greater ease to themselves.

In each of the cases the automatic regulation of the motors was perfect.

In this connection a comparative schedule of charges for current for small motors in Chicago and several other cities will be of interest.—*Western Electrician.*

Schedule of charges per month in dollars for current for small motors.

Horse Power.	1/10	1/8	1/4	1/2	1	1½	2	3	4	5	6	7	8	9	10
Chicago, Ill...	$5	$5	$5	$6.50	$10		$20	$30	$38	$46	$53	$60	$67	$74	$80
Milwaukee....	......	2.50	3	5	10	......	20		30	......	45	......	......	......	65
Cleveland.....	......	......	......	......	8	......	15	21	26.50	32	37.50	......	......	......	......
New York....	......	......	......	6	10	$15	20	25	......	40	......	......	55	......	65
Baltimore...	......	2.50	3	5	10	......	20	......	30	......	45	......	......	......	65
Grand Rapids	......	2	......	6	10	......	16.66	......	29.11	......	41.11	......	......	......	......
St. Louis. ...	......	......	4.35	7.60	10.85	......	21.70	29.90	39.85	47.65	......	63.70	......	......	86.65

THE TELEPHONE.

The executive committee has decided that the next meeting of the National Telephone Exchange Association, which will be held in the city of New York, shall commence on Tuesday, September 4th, 1888. Further details of the arrangements will be announced from time to time as they are perfected.

The Ohio Valley Telephone Co. is laying pipes from the rear of the Telephone Exchange, on Green street, to Eighth and Main streets, Louisville, Ky. The company will place all the wires in the central part of the city underground, doing away with a great many telephone poles. The business of the company has increased so materially during the past few years that the present poles are almost inadequate to sustain their weight.

In the settlement of the telephone difficulties of Rochester, N. Y., an advance is agreed upon of about 10 per cent., upon rates prevailing before the "strike." The permission to occupy the streets and public places for poles or underground conduits is given. In alluding to this settlement in our last number, the following important point, which will interest all telephone companies, was not stated. The company agrees to do one-half mile of underground work each year until three miles are completed and the subscribers agree to pay 50 cents per annum additional for each half-mile of conduit laid until two miles are in use, thus increasing their rate $2.00 per annum on account of underground work. Subscribers are returning rapidly, and the company is installing multiple switch-boards with a view to the improvement of the service.

Telephone exchange statistics from the circular of the American Bell Telephone Co., May 1, 1888.

	Schedule A		Schedule B		Schedule C		Schedule D		Total. Comparative statement for three years.		
	Population over 150,000.		Population from 50,000 to 150,000.		Population from 10,000 to 50,000.		Population of 10,000 and under.				
	Jan. 1, 1887.	Jan. 1, 1888.	Jan. 1, 1887.	Jan. 1, 1888.	Jan. 1, 1887.	Jan. 1, 1888.	Jan. 1, 1887.	Jan. 1, 1888.	Jan. 1, 1886.	Jan. 1, 1887.	Jan. 1, 1888.
Number of exchanges....	16	16	25	26	193	192	502	505	747	736	739
Number of circuits.......	35,561	39,791	19,930	22,163	42,073	44,981	23,696	25,069	112,067	121,260	132,004
Number of miles of wire..	49,479	57,244	19,194	23,386	37,298	41,429	22,260	24,379	114,046	128,231	146,438
Number of employés......	2,125	2,258	840	894	1,609	1,751	1,269	1,285	5,488	5,843	6,183
Number of subscribers....	42,482	47,030	26,801	29,068	51,021	54,232	26,764	28,382	137,750	147,068	158,712

The entire number of offices in the exchange systems, in operation January 1, 1888, was 1,191.

The much vaunted Van Rysselberghe system has at last been abandoned on the Swiss lines between Geneva and Lausanne and between Zurich and Bale, where independent telephone lines will henceforth be employed. The system seems to have come far short of the expectations of its promoters in both efficiency and economy. Dr. Rothen, co-director of the Swiss telegraphs is reported as saying :—

"The Rysselberghe system has certain weak points. The apparatus is especially delicate, particularly the condensers. A relatively slight atmospheric discharge may destroy them completely. It has, therefore, been necessary to apply lightning rods which can transmit the atmospheric discharges more easily than the condensers; but then these rods easily become deranged, as a slight atmospheric discharge may put the telegraphic line in communication with the earth, and, in spite of the great sensitiveness of the lightning rods, the condensers are sometimes destroyed. The Rysselberghe system affects the telegraphic service in an annoying manner. At the outset it is necessary to increase the batteries of the telegraphic stations considerably; but a worse point is that the telegraphic service is delayed by the increased duration of the variable state of the currents. The Morse service generally does not suffer, but the transmission on the Hughes system is often deranged, and the service of the rapid apparatus, such as the Wheatstone, is probably impossible.

"From a telephonic point of view, the transmissions are very faint, at least with ordinary apparatus, and the silence of the telegraphic signals is, so to speak, obtained only in theory.

"The cost of the installation of the system is not so trifling as it is sometimes believed. Its application on the telegraphic line from Geneva to Lausanne cost about 15,000 francs."

At St. Louis the Missouri Bell Telephone Co. was early in June a defendant in a case in the police court for violating the ordinance prohibiting telephone companies from charging more than $50 a year for use of an instrument. Judge Cady held that the ordinance was legal and all right, and fined the telephone company $300. The directors of the St. Louis Bell Telephone Co. refuse to make any new contracts; as contracts expire at the rate of about a dozen each day, a dead-lock in the telephone service is threatened. The company promptly removed twelve telephones from the municipal departments. The mayor threatens to chop down the poles and wires while the company defies him, claiming to derive its privilege from the state.

At Hopkinton, Mass., on the 24th of May, the telephone switch-board was burned out and completely ruined by the wires getting crossed with an electric light wire.

At Washington, the National House of Representatives has

made an appropriation of $36,000 for putting the District telegraph and telephone wires underground. On June 13th the senate concurred, with an amendment striking out the clause which required all telephone and telegraph and other wires to be removed from the streets, wherever the District wires shall have been removed. The bill now goes back to the house, to see whether that body will agree to the striking out of this provision.

ELECTRIC LIGHT AND POWER.

OMAHA, Neb., is to have a new electric lighting company. Mr. G. Pantaleoni, of the Westinghouse Electric Co., has been recently in that city completing arrangements for putting in the large plant to be furnished by the Westinghouse company.

THE FORT WAYNE JENNEY alternating plant at Harlem, N. Y., was recently tested by a disinterested electrician and was found to be furnishing 13 lights to the horse-power.—*Western Electrician,*

THE BRUSH ELECTRIC LIGHT CO.'s suit against Owen Pixley & Co., of Indianapolis, which involves the entire arc system of electric lighting, was dismissed by Judge Gresham, June 5th, for want of equity. Although Owen Pixley & Co. are the nominal defendants, the real defendants are the Jenney Electric Light Co., of Fort Wayne, who put in the plant in controversy, and all others who use the arc system. Judge Gresham's opinion is as follows :—

"1. The invention is shown in the patents, 212,183 and 219,208, but in 212,183 the examiner held that Brush's claims were too broad. The decision was acquiesced in, and the invention which was there described, claimed and rejected, is now claimed in the patent sued on. The rejected invention was dedicated to the public by acquiescence in the ruling of the examiner, and cannot be claimed in a subsequent patent against others who meantime entered the field and used the rejected invention.

"2. The patent in suit is limited to solenoids and cores mechanically opposed, and it does not include the common or electro-magnet, and thus construed, the patent sued on is not infringed by the defendants."

MR. ELIAS E. RIES, of Baltimore, has contrived a new inductorium or transformer, adapted for regulation within wide limits. The invention is described in U. S. patent No. 380,138, March 27th, 1888, issued to Mr. Ries—to which our readers are referred —our space not permitting fuller notice at this time.

A DESPATCH from Washington states that arrangements have now been pefected by the Lighthouse Board for the illumination of buoys in New York harbor, and that contracts for the work will be made at once. There will be six buoys lighting the channel and furnished with current from the plant at Sandy Hook light station. The plant is to cost altogether about $20,000, and the cost of the maintenance is put at about $3,000 a year. It is believed that when the arrangements have been perfected ships will be able to come through Gedney Channel as easily by night as by day.—*Electrical World.*

Foreign.

Austria.—CENTRAL STATION LIGHTING BY WATER POWER.—A central electric light station is being installed in Trient, Austria, the power to be supplied by a tributary of the Etsch. The waterfall is 2,000 yards from the centre of the town, and 330 feet above it. The water for the turbines is carried by a tunnel 2,000 feet long to an artificial reservoir of 900 tons capacity, and the supply is at the rate of 1,600 gallons per minute. From the reservoir the water is carried by iron tubes of 35 inches diameter to the turbine house, 2,700 feet distant. The lower portions of the supply main have a pressure of 120 pounds per square inch ; they have been tested up to 375 pounds. The sluice valve at the lower end of the supply main is subjected to a total pressure of 164 tons. The total power available varies from 800 h. p. to 400 h. p., according to the season and climatic conditions. The power required for lighting purposes is estimated at 240 h. p., and the town authorities who are carrying out this work propose to utilize an average of 300 h. p. in the day time, and 150 h. p. in the evening for working motors. The tunnel and reservoir have cost 122,000 florins, and the central station is estimated at 98,000 florins, making a total of 220,000 florins. The working expenses, including depreciation and interest, are estimated at 48,000 florins, and to cover this expenditure the light would be supplied at the rate of 3.75 kreuzer, or say about 7d. per 16 c. p. lamp hour ; but when a greater number of lamps are taken up by the subscribers the town will be able to reduce the cost per lamp hour considerably below the figure quoted. The installation is to be in working order in November next.

Italy.—THE ALTERNATING CURRENT SYSTEM WITH UNDERGROUND CONDUCTORS IN ITALY.—Mr. Emilio Mayatti, of Rome, in a letter printed in *Engineering* March 24, states that three central station electric light installations of considerable size are now operating in Italy, using the alternate current and transformer system and underground conductors. The largest of these plants is that of the Anglo-Roman Gas Company, which now lights daily upwards of 5,000 incandescent lamps, and is constantly extending its service.

All the underground conductors for these installations have been manufactured by the house of Siemens and Halske, of Berlin, who have taken special precautions for insuring a trustworthy service. The cables are composed of two highly insulated concentric conductors, protected against external and mechanical injuries by a lead sheath and a double spiral band of iron. Upwards of 40,000 meters of such conductors have been laid in Italy alone.

PERSONAL MENTION.

MR. E. M. BARTON, president of the Western Electric Co. of Chicago and New York, sailed for Europe, June 27th, with his family. Mr. Barton will, it is understood, spend a few months in Continental travel, giving some attention to business meanwhile —returning to Chicago before Winter, after establishing his family in Germany, for a year or so, for special educational facilities.

MESSRS. BALDWIN, DAVIDSON & WIGHT, attorneys-at-law and solicitors of patents, 25 Grant place, Washington, D. C., and 38 Park row, New York, succeeded, April 1 last, to the business of the long established firm of Baldwin, Hopkins & Peyton, of Washington.

Mr Baldwin formed an association with Edward C. Davidson, of the late firm of Baldwin & Davidson, of New York, and Lloyd B. Wight, attorney-at-law, of Washington, who was for many years connected with the old firms.

Baldwin, Davidson & Wight retain the offices, books, papers and employés of both firms, and conduct patent soliciting and litigation in all branches at both places under the firm name of Baldwin, Davidson & Wight.

MR. EDWARD E. HIGGINS, formerly of the Standard Electric Co., St. Johnsbury, Vt., some weeks ago accepted a position with the Sprague Co., as managing agent for Western N. Y., with headquarters at Buffalo. We congratulate the Sprague Co. on the acquisition of Mr. Higgins to their staff. His ability and energy are well approved.

MANUFACTURING AND TRADE NOTES.

THE ELECTRICAL SUPPLY CO. having discontinued their New York office, announce that they have made Messrs. T. F. Hunter & Co. their New York agents. Mr. Hunter's six years' experience with the house is a guarantee that the business will be promptly and carefully attended to. Messrs. T. F. Hunter & Co. announce that they have taken, and now occupy, since May 1, 1888, the store 37 Church street, New York.

MESSRS. SHIELDS AND O'ROURKE, of 98 Fifth avenue, Pittsburgh, Pa., have started in business as contractors and builders of overhead lines for electric street railways. They have already built the lines of the Bentley-Knight road at Allegheny City, and they are now reconstructing the lines of the Daft road at Asbury Park, N. J. Both Mr. Shields and Mr. O'Rourke have had experience of practical work in building telegraph and electric light lines.

THE SPRAGUE ELECTRIC RAILWAY AND MOTOR CO. have received an order from the U. S. government for motors for use in the naval service, and an installation is to be made at once on board the U. S. steel cruiser "Chicago," of motors to be used in the training and elevation of the guns. The electrical and mechanical apparatus required for this work will have to be of the most perfect construction; and the Sprague company may feel honored in having been selected to accomplish the required results.

MESSRS. PARTRICK AND CARTER'S new catalogue of electrical apparatus and supplies is a very comprehensive list. Like other old established electrical houses, they have widened the scope of their business with the constantly increasing number of applications of electricity to useful purposes.

THE HALL ELECTRIC PUMP CO., Plainfield, N. J.—New York office 195 Tribune building—are offering a very compact apparatus consisting of a rotary pump and an electric motor mounted on one base and joined up by a worm gear. A "C & C" motor is shown in the illustration of their circular. The whole gives the impression of an exceedingly useful combination for elevating water in building accessible electric light or power circuits.

MESSRS. P. A. DOWD & CO., No. 239 Broadway, New York city, agents, Sprague Electric Railway & Motor Co., report the following among recent sales of the standard motors for elevators :—Brown & Rittenhouse, 139 Reade street, 10 h. p.; Jno. A. Willet & Co., 137 Reade street, 10 h. p.; Rufus L. Cole, 141 Reade street, 5 h. p.; P. Dauphin, for machinery, 151 Fulton street, ½ h. p.; Lehr & Lock, 37 John street, 1 h. p.; Heller & Birdel, 23 Maiden lane, 1 h. p ; Jno. Robinson & Co., for elevator, 45 Murray

street, 2 h. p.; C. G. Braxmar, 36 Cortlandt street, 1 h. p.; Lazell, Dalley & Co., for elevator and machinery, 110 Beekman street, 7½ h. p.; Kalle & Co., 77 John street, 5 h. p.: Jas. S. Barrow & Co., for elevators, 141 Chambers street, 5 h. p.; Gold & Stock Tel. Co., for transmitters, 16 & 18 Broad street, 5 h. p.; Thurber, Whyland & Co., for printing presses, 143 Chambers street, 3 h. p.; Whitelaw Reid, pumps etc., Ed. *Tribune*, 2 h. p.

THE WATERHOUSE ELECTRIC AND MANUFACTURING Co., of Hartford, Conn., have issued a new catalogue, and show great progress during the past year in their arc lighting system. The dynamo is compact, and of the Gramme type, being series wound; the regulator is a most important part of the system. In regulating, the brushes have a fixed position on the commutator. There are three brushes—two main and one auxiliary brush. The current from the armature is carried in two circuits to the lamp line. The field circuit starts from the armature at the upper main brush and passes around the field magnets of the dynamo and to the point where it joins the local circuit. The local circuit leaves the armature by way of the auxiliary or upward forward brush and joins the current from the field circuit, the sum of the two currents being the amount passing through the lamps. After passing through the lamps the current from both the field and local circuits returns to the armature by way of the lower main brush. When lamps are turned off, instead of an increased current passing around the field magnets, which would be the usual result, the current is automatically reduced and the current in the local circuit is increased in a like proportion; so that on the lamp circuit the current passing through the lamps is the same whether one lamp or the full number are burning. A uniform light can therefore be maintained. As an example, if the field circuit shows six amperes and the local circuit four amperes, the lamp circuit would have the sum of the two or ten amperes. If any number of the lamps are turned off, an instant change occurs in the field circuit, and we will say enough are turned off to reduce it to four amperes. The local circuit would then show an increase to six amperes and no difference would be seen in the lamps because the sum of the two currents equals ten, the same as at first. It is readily seen that the current cannot build up in dynamos so regulated.

The Waterhouse company announce their willingness to show at their factory that the above changes occur in the current on the local and field circuits. All of their central station plants are said to turn off lights at will, without the current building up.

ELECTRIC STREET RAILWAYS IN AMERICA

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horse-power; **T.**, T rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P Scaife; *Sec.*, Arthur Kennedy; *Tr.*, Jas. B. Scott; *Supt.*, Alexander Moffat; *Eng.*, ——; 3-7 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 200 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½: 45 lb.; 3 m. c.; 1 m.; sta. —— h. p.: overhead cond. THOMSON-HOUSTON.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Tr.*, F. W. Harriman; *G. M.*, A. A. Jöhnson; *Eng.*, N. M. Edwards; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; sta., 60 h. p.; water power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Birmingham, Ct.—Derby Horse Railway Co.—*Pr.*, H. H. Wood; *Sec.*, Wm. J. Clark; *Treas.*, Chas. E. Clarke; 4 mi.; 94′ 8½″; m 5; c. 4; h. p. 100. VAN DEPOELE.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; *G. M.*, John Aldrich; 5 mi.; g. 4-8½; 30 and 60 lb.; 3 m. c.; 1 m.; steam power; sta. 75 h. p.; overhead cond. SPRAGUE.

Columbus, O.—Columbus Consolidated Street Ry. Co.—*Pr.*, A. D Rodgers; 2 mi.; g. 5-2; 2 m. c.; 30 lbs.; 2 c.; sta., 250 h. p.; underground conduit. SHORT.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g.——; 30 lb. T; 4 m. c.; sta. —— h. p.: overhead cond. VAN DEPOELE.

Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; *Supt.*, Mr. Richardson; 1 mi.; g. 5-2; 35 lb.; 2 m. c.; sta. 40 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1 c.; 1 m.; sta. —— h. p.; conduit cond. VAN DEPOELE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, D. W. Burdick; *Sec.*, J. Murray Mitchell; *Tr.* T. F. Van Fleet; 1 mi.; g. 4-8½; 30 lb. T.; 2 m. c.; sta. 20 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Lafayette, Ind.—Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2.25 mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Meriden, Conn.—New Horse R. R.—*Pr.*, T. J. Lathram; *Sec.* and *Tr.*, T. A. Lamb; 5 mi.; g. 4-8½; 35 lb.; 12 m. c.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. THOMSON-HOUSTON.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. THOMSON-HOUSTON.

Richmond, Va.—The Richmond Union Pass. Ry. Co.—*Pr.*, W. R. Trigg; *Sec.* and *Tr.*, Andred Pizzini; *G. M.*; G. A. Burt; *Eng.* A. L. Johnston; 18 mi.; g. 4-8½: 45 lb.; 40 m. c.; sta. 400 h. p.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. McMaugh; *Eng.*, W. S. Smith; 5.75 mi.; g. 4-8½; 30 lb.; 4c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

St. Joseph, Mo.—Union Ry. Co.—*Pr.*, Seymour Jenkins; *Sec.* and *Tr.*, A. Steinacker; *Supt.*, Chas. Wilson; 9½ mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Tr.* T. F. Torrey; *Supt.* and *G. M.*, B. T. Killam; *Eng.*, J. Nazel; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 14 m. c.; sta. 300 h. p.; overhead cond. THOMSON-HOUSTON.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond. THOMSON-HOUSTON.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—7 mi.; g. 5-2; 50 lb.; 3 m. c.; overhead cond. SPRAGUE.

Wilmington, Del.—Front & Union St. Ry. Co.—*Pr.*, G. W. Bush; *Supt.*, S. A. Price; *Tr.*, E. T. Taylor; g, 5-2; —— lb.; 7 p. c.; operated by mules. SPRAGUE.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.5 mi.; g. 3-6; 25 lb.; 1 c.; 1 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb. T; 1 m. c.; sta. 1,000 h. p.; overhead cond. THOMSON-HOUSTON.

Constructing or Under Contract.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—*Pr.*, H. G. Bacon; *Tr.*, J. E. Draper; *G. M.*, H. M. Daggert, Jr.; 6 mi.; g. —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond.

Brockton, Mass.—East Side St. Ry. Co.—*Pr.*, A. F. Small; *Clerk*, C. A. Noyes; *Tr.*, C. D. Fullerton; *Eng.*, E. L. Brown; 4½ mi.; g. 4-8½; 40 lb.; 4 m. c.; steam-power sta. 60 h. p.; overhead cond. SPRAGUE.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown; *G. M.*, E. Scott; 4 mi.; g. 4-8½; 25 lb.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper; *Sec.*, J. R. Murdock; *Tr.* and *G. M.*, G. B. Kerper; *Supt.*, R. Palley; *Eng.*, H. Kolf; 1 mi.; g. 5-2½; 52 lb.; 3 m. c.; 3 m. overhead.

Davenport, Iowa.—3.5 mi.; 8 m. c.; overhead cond. SPRAGUE.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. THOMSON-HOUSTON.

Elsinore, Cal.—Elsinore Lake Shore Elect Ry. Co.—*Pr.*, D. G Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.

Erie, Pa.—Erie City Pass. R. R. Co.—*Pr.*, W. W. Reed; *Sec.*, J. L. Sternberg; *Supt.*, Jacob Borst.

Flushing, N. Y.—Flushing & College Point St. R. R.—*Pr.*, J. Dykes; *Sec.*, Charles Frey; *Tr.*, Henry Clement; g. 4-8½; 45 lb.; 1 mi.; storage bat's.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; 6 m. c.; overhead cond. SPRAGUE.

Lakeside, O.—3 mi.; 2 c.; overhead cond.

Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi.; g. 4-8½; 56 lb.; 10 m. c.; storage bats.

Louisville, Ky.—Central Pass. R. R. Co.—*Pr.*, B. du Pont; *Sec.*, J. C. Donigan; —— mi: g. 5.

Meriden, Conn.—Meriden Horse R.R. Co.—*Pr.*, Geo. R. Curtis; *Sec.* and *Tr.*, C. L. Rockwell; *Supt.*, D. Barker; 5 mi.; g. 4-8; 35 lb.; 12 m. c. DAFT.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W, Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.

New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*, E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.

New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.

Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.

Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.

Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.

Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, F. H. Skeele; *Sec.*, E. H. Cook; *Tr.*, C. D. Newton; *V. P.*, M. Dillon; *Supt.*, T. M. Burt; 3 mi.; g. 4-8½; 38 lb.; 5 m. c.; overhead DAFT.

Revere, Mass.—Lynn & Boston R. R.—Ocean Ave. line; overhead cond. THOMSON-HOUSTON.

Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.

St. Louis, Mo.—Lindell Ry. Co.—*Pr.*, J. H. Lightner; *Supt.*, G. W. Baumhoff; *Eng.*, E. J. Bagnall; —— mi.; g. 4-10; 65 lb.; 1 m. c.; 2 m.; 3 p. c.; storage bats.

Sacramento, Cal.—Sac. Elect. Ry. Co.

Salem, Mass.—Naumkeag St. Ry. Co.—*Pr.*, C. Odell; *Tr.*, H. Wheatland; *Sec.*, J. F. Hickey; *Supt.*, W. B. Furgurson; 1½ mi.; g. 4-8½; 6 m. c.; 35 lb.; 80 p. c.; sta. 100 h. p.; overhead cond. SPRAGUE.

San Jose, Cal.—San Jose Motor Co.—*Pr.*, J. W. Rea.

Sault Ste. Marie, Mich.—S. St. M. St. Ry. Co.—*Pr.*, E. M. Lacy; *Sec.*, F. Ryan; *G. M.*, L. G. Cody; 2 mi. FISHER.

Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.*, A. Frothingham; *Tr.*, G. A. Jessup; *Supt.* and *Eng.*, T. Gibbs; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; steam power; sta. 250 h. p.; overhead cond. VAN DEPOELE.

South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.

Springfield, Mo.—2 mi. FISHER.

Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; *G. M.*, H. McGonegal; 4 mi.; g. 4-8½; 8 m. c.; 4 p. c.; steam power; sta. 250 h. p.; overhead cond. THOMSON-HOUSTON.

Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

Notes.

THE BROOKLYN, N. Y., common council has granted permission to the Brooklyn City Railroad Co. to run five electric motor cars over the tracks on Third avenue, from Twenty-fifth to Thirty-ninth street.

THE REPORT of the Richmond Union Passenger Railway for the month of May, shows number of miles run, 50,430; passengers carried, 242,282. The total operating expenses, including everything, are given as only 47 per cent. of the receipts.

THE LOCAL THOMSON-HOUSTON ELECTRIC LIGHT CO. has bought the Hoosac Valley Street Railway, running from North Adams, Mass., to Adams. The purchasers paid $75,000. A plant costing $50,000 will be erected to run the road by electricity. There is talk of an electric railway between North Adams and Williamstown.

AT SAN DIEGO, CAL., there are four and a half miles of electric road in operation, half a mile in construction, and 18½ miles projected The San Diego Electric Rapid Transit Street Car Co. has asked for a franchise to construct feeders on Sixth and Arctic streets.

CARBONDALE, PA.—The Carbondale and Jermyn Street Railway Co. are about to add eight electric motor cars to their equipment and to extend their road.

APPLETON, WIS.—The Appleton Electric Street Railway Co. have had two years of perfect success, and say they save 50 per cent. over animal power.

ITHACA, N. Y.—The Ithaca Street Railway Co. are expecting to extend their line several miles at an early date. The system works well.

PITTSBURGH, PA.—The Pittsburgh, Knoxville & St. Clair Street Railway, went into regular operation June 25th, but in consequence of financial trouble experienced before it begun operations, has gone into the hands of a receiver, and the running of the road has been suspended.

RICHMOND, VA.—The Richmond Union Passenger Railway Co. is extending its road two miles to the Exposition grounds.

KANSAS CITY, MO.—We are advised that the Henry system electric railway at Kansas City, after some months suspension of operation has been definitely abandoned. The conductors have been taken down and the line will be operated by steam dummies. Bad engineering and financiering are assigned as causes of the failure.

AMESBURY, MASS.—It is reported that a company is forming to build an electric railway from Amesbury to Salisbury Beach and from Amesbury through Merrimac to Haverhill.

CLEVELAND, OHIO.—The East Cleveland Railroad Co. has applied for an ordinance permitting the use of electric motors on the Euclid avenue line from Willow avenue to the city limits, and also on the Cedar avenue line.

THE SPRAGUE CO. have closed the contract for equipping the Hartford and Weathersfield railway.

SUPERINTENDENT ALDRICH, of the Carbondale electric road, has made a remarkable record with one of his cars, which is now running its 16th consecutive day without change or filing of brushes. Ordinarily the brushes on a railway motor, with other systems, are expected to need changing or replacing at least once a day and many times oftener, and so this "feat" is something out of the usual line of occurrences and shows what the Sprague motor with judicious and careful handling can do.—*Carbondale Leader*, June 12.

WICHITA, KAS.—The Riverside and Suburban Railway Co. is operated at present by animal power.

DENVER, COL.—The Denver Tramway Co. is abandoned, and is being replaced with 12 miles of the Lane system cable railway.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From May 22 to June 12, 1888 (inclusive).

Alarms and Signals:—*District Telegraph Call-Box*, J. B. Gill, 383,220, May 22. *Electric Alarm Clock*, E. J. Colby, 383,439. *Annunciator*, F. E. Fisher, 383,566. *Electrical Needle Annunciator*, W. E. Gill and R. Segerdahl, 383,-725, May 29. *Electric Signaling Box*, W. D. Browne, 383,941. *Boiler-Alarm*, J. J. Ghegan, 383,946. *Electric Annunciator*, C. E. Scribner, 384,088. *Magneto-Electric Liquid-Level Indicator*, J. J. Ghegan, 384,200. *Fire-Bucket Low-Water Alarm*, J. Nolan, 384,212, June 5. *Electrical Annunciator*, H. S. Downerd, 384,430. *Police Electric Signal System*, C. E. Scribner, 384,476, June 12.

Clocks:—*Circuit Closing Device for Electric Clocks*, C. H. Pond, 383,655. *Electric Apparatus for Winding Clocks*, M. Viau, 383.786, May 29. *Electric Pendulum Clock*, A. L. Parcelle, 384,271. *Electric Winding Attachment for Clocks*, A. J. Reams, 384,472, June 12.

Conductors, Insulators, Supports and Systems:—*Anti-Induction Composition for Electric Cables*, D. Brooks, Jr., 383,096. *Support for Electric Wires*, same, 383,097. *Covering for Electric Wires and Cables*, same, 383,-098, May 22. *Insulator for Electric Wires*, F. E. Keyes, 383,734. *Crawler for Electric or Other Conduits*, H. G. Morris, 383,756, May 29. *Insulated Wire*, H. Splitdorf, 383,919, June 5. *Machine for Covering or Insulating Wire*, J. D. Thomas, 384,404, June 12.

Distribution:—*Production, Transmission and Distribution of Electric Currents*, C. E. Fritts, 383,520. *Combined Alternate Current and Storage System of Electrical Distribution*, H. M. Byllesby, 383,620. *Alternate Current and Storage System of Electrical Distribution*, same, 383,621 and 383,-622. *Combined Alternate-Current and Storage System of Electrical Distribution*, same, 383,623. *Circuit Controlling Apparatus for Electric Lighting Circuits*, O. B. Shallenberger, 383,661. *Coupling of Alternate-Electric-Current Generators*, same, 383,662, May 29.

Dynamos and Motors:—*Dynamo-Electric Machine*, J. W. Easton, 383,113. *Automatic Tightening Device for Armatures, of Dynamo-Electric Machines*, same, 383,114. *Dynamo-Electric Machine*. L. N. P. Poland, 383,320, May 22. *Armature for Electric Motors*, F.E. Fisher, 383,564. *Dynamo-Armature*, same, 383,565. *Armature for Dynamos*, same, 383,567. *Armature for Dynamos and Motors*, H. M. Byllesby, 383,617. *Synchronizing Device for Alternate-Current Dynamos*, same, 383,618. *Armature for Dynamos and Motors*, same, 383,619. *Apparatus for Connecting Alternate-Current Dynamos*, P. Lange, 383,648. *Governor for Electric Motors*, R. H. Mather, 383,651. *Bobbin for the Field Magnets of Dynamos*, A. Schmid, 383,657. *Brush-Holder for Electric Generators*, same, 383,658. *Armature for Dynamos*, A. Schmid and H. M. Byllesby, 383,659; O. B. Shallenberger, 383,663. *Armature for Electric Machines*, same, 383,664. *Mounting Armatures of Dynamos*, G. Westinghouse, Jr., 383,679. *Current-Collector for Electric Machines*, W. Stanley, Jr., 383,832, May 29. *Governor for Electro-Magnetic Motors*, C. F. Brush, 383,857. *Dynamo-Electric Machine or Motor*, A. L. Riker, 384,077. *Governor for Electric Motors*, W. Baxter, Jr., 384,117, June 5.

Galvanic Batteries:—*Galvanic-Battery Excitant*, T. P. Whittier, 383,263. *Battery Zinc*, J. Beattie, Jr., 383,271, May 22. *Electric Battery*, E. A. Wildt, 383,548. *Galvanic Battery Fluid*, H. J. Von Metzradt, 383,677. *Galvanic Battery*, H. B. Cox, 383,706, May 29.

Lamps and Appurtenances:—*Manufacture of Incandescent Electric Lamps*, O. A. Moses, 383,140. *Combined Gas and Electric Light Fixture*, S. B. H. Vance, 383,158 and 383,332. *Electric Lamp*, E. C. Ohmart, 383,411, May 22. *Manufacture of Filaments for Electric Incandescent Lamps*, J. W. Packard, 383,484. *Carbon Conductor for Electric Lamps*, H. J. Von Metzradt, 383,602. *Incandescent Lamp*, H. M. Byllesby and P. Lange, 383,616. *Manufacture of Incandescent Electric Lamps*, E. P. Thompson, 383,675. *Evacuating Electric Lamps*, same, 383,676, May 29. *Cut-Out for Incandescent Lamps*, H. Lamp and M. J. Wightman, 383,891, June 5. *Incandescent Lamp Socket*, J. Spink and C. Gauzentes, 384,478, June 12.

Measurement:—*Differential Expansion Device for Galvanometers*, W. H. Bristol and W. E. Geyer, 383,095, May 22. *Galvanometer*, R. E. B. Crompton and G. Kapp, 383,444. *Voltmeter*, P. Lange, 383,649. *Electric Meter*, G. Westinghouse, Jr., 383,678. *Electric Meter*, G. Westinghouse, Jr. and P. Lange, 383,680, May 29.

Medical and Surgical:—*Electro-Therapeutic Battery*, E. J. Murphy and J. Floyd, 383,899, June 5. *Electric Comb*, C. Busch, 384,561, June 12.

Metallurgical:—*Magnetic Separator*, G. Conkling, 383,8'3; M. H. Smith, 383,918. *Electro-Magnetic Separator*, J. B. Hamilton, 384,035, June 5.

Miscellaneous:—*Electrophorus*, J. D. Culp, 383,105. *Electrical Apparatus for Purifying Water*, A. R. Leeds, 383,184. *Combined Doll and Phonograph*, W. W. Jacques, 383,299. *Fusible Coupling for Electric Fire-Alarm Circuits*, G. G. Smith, 383,377. *Rheostat*, F. J. Crouch, 383,345. *Testing Machine*, A. V. Abbott, 383,385, May 22. *Retouching Device*, G. F. Card, 383,436. *Thermo-Electric-Generator*, R. J. Gulcher, 383,464. *Electric Punch Register*, A. C. Palmer, 383,485. *Thermo-Electric Apparatus for Controlling the Temperature of Water in Pipes*, E. A. Newman, 383,536. *Electro-Magnetic Register*, J. F. McLaughlin, 383,583. *Apparatus for Testing Electric Circuits*, A. D. Wheeler, 383,605. *Electric Cigar Lighter*, R. Belfield, 383,611. *Switch for Adjustable Resistances*, P. Lange, 383,647. *Indicator for Electric Circuits*, O. B. Shallenberger, 383,665. *Apparatus for Detecting Ground-Connections in Electric Circuits*, same, 383,666. *Method of Indicating Electric Currents*, same, 383,667. *Electrical Indicator for Alternating Electric Currents*, same, 383,668. *Electrical Indicator*, same, 383,669, 383,670 and 383,671. *Method of Indicating Electric Currents*, same, 383,672. *Gas-Engine*, C. Sintz, 383,775. *Electric Smelling Bottle*, C. T. Brown. *Device for Preventing Incrustation in Steam-Boilers*, W. B. Bull, 383,795, May 29. *Electric Power Controller*, G. S. Neu, 383,901. *Rheostat*, E. W. Rice, Jr., 383,913. *Switch or Cut-Out for Electric Circuits*, J. J. Wood, 383,933. *Lightning Arrester*, P. O. Keilholtz, 384,042. *Rheostat*, W. H. Knight, 384,044. *Electric Shunting Device*, W. Baxter, Jr., 384,116. *Demagnetizer*, J. Greaves, 384,152, June 5. *Metallic Crest-Tile Lightning Rod*, C. B. Nelson, 384,384. *Electric Circuit-Controller*, O. F. Greim, 384,440. *Electric Circuit-Closing Device*, M. W. Grovesteen and F. G. Jahn, 384,570, June 12.

Railways and Appliances:—*Electrical Tramway*, H. T. Blake, 383,273; H. T. Blake and C. Sterling, 383,274, May 22. *Apparatus for Lighting Railway Cars by Electricity*, I. A. Timmis and S. C. C. Currie, 383,502. *Propelling Vehicles by Electricity*, C. A. Faure, 383,561. *Underground Conduit and Grip for Electric Railways*, E. E. Ries and A. H. Henderson, 383,770. *Overhead Conducting System for Electric Railways*, G. T. Woods, 383,844, May 29. *Electric Railway*, G. H. Condict, 384,562; R. M. Hunter, 384,576. *Apparatus for Electric Traction*, E. Julien, 384,580. *Electric Railway Car*, same, 384,581. *System of Electric Locomotion*, H. A. Seymour, 384,594, June 12.

Storage Batteries:—*Secondary Battery*, S. Russell, 383,150; J. S. Sellon, 383,-193; L. Epstein, 383,216, May 22; C. A. Faure, 383,560 and 383,562. *Manufacture of Secondary Batteries*, R. M. Hunter, 383,575. *Storage Battery Plate*, C. D. P. Gibson, 383,640. *Method of Filling Secondary Battery Plates*, H. G. Morris and P. G. Salom, 383,757, May 29. *Automatic Switch for Secondary Batteries*, J. S. Sellon, 384,289. *Regulating Commutator for Secondary Batteries*, E. Julien, 384,447, June 12.

Telegraphs:—*Printing Telegraph*, S. V. Essick, 383,450. *Relay*, J. E. Watson, 383,843, May 29 and 384,222, June 5. *Printing Telegraph*, E. J. Mallett, 384,320. *Polarized Electro-Magnet*, same, 384,321. *Printing Telegraph*, same, 384,-322. *Automatic Pole Changer*, same, 384,323. *Automatic Telegraphy*, same, 384,324 and 384,325. *Automatic Pole Changer*, same, 384,326. *Combined Telegraph Key and Sounder*, J. Doggert, 384,350. *Printing Telegraph Receiver*, H. Mahnken, 384,455, June 12.

Telephones, Systems and Appliances:—*Mechanical Telephone*, G. F. Shaver, 383,324. *Telephone-Conveyer*, S. R. Ballard, 383,269, May 22. *Test-Switch for Multiple Switch-Boards*, C. E. Scribner, 383,495. *Telephone Call-Bell System*, F. E. Fisher, 383,563, May 29. *Telephone Transmitter*, E. T. Gilliland, 384,201, June 5. *Multiple Switch-Board Circuit*, C. E. Scribner, 384,477, June 12.

THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS.

Published Monthly at

11 Wall Street, New York City.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies, -		.30

[*Entered as second class matter at the New York, N. Y., Post Office, April 9, 1888.*]

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VOL. VII. NEW YORK, AUGUST, 1888. No. 80

TRANS-ATLANTIC ELECTRICAL LITIGATION.

TWO important cases have recently been decided in the English law courts, which may perhaps come to have an important influence upon the future of electrical lighting in that country, and which may possibly be not without some ultimate effect upon similar interests upon this side of the Atlantic. The first of these, in respect to priority of the date of judgment, related to the patent of Gaulard & Gibbs for the distribution of electricity by alternating generators and converters. The circumstances attending the institution of this action, which was on a petition for the repeal of the patent, appear to have been somewhat peculiar. It seems that a corporation known as Sir Coutts Lindsay & Co., working an installation having its central station at the Grosvenor Gallery, in London, originally equipped their system with the Gaulard & Gibbs appliances, having the converters arranged in series on the line. This was done under a contract, whereby the patentees were to be paid a stipulated royalty for every electrical horse-power installed. After the plant had been some time in operation it was placed by the company in charge of an electrician named Ferranti, who subsequently reorganized the plant, placing the converters in parallel and substituting, in part at least, new converters of his own design. A dispute, which in time arose concerning the matter of royalties, led to a cancellation of the contract and a refusal on the part of the licensees to pay further royalties. As a result of this, an action for infringement was commenced by the patentees, while at about the same time Ferranti obtained leave to bring a cross-action for the repeal of the patent. This proceeding appears to have given rise to considerable comment, inasmuch as the real plaintiffs in the case were Sir Coutts Lindsay & Co.; but since the payment of licenses under the patent estopped them from denying its validity, the action was ostensibly brought by an employé. The patent act expressly enumerates, among those who are disqualified to bring such an action, the patentee of a subsequent and subordinate patent. This disqualification was however got over by obtaining a special leave from the Attorney-General to bring the action; a circumstance which has caused much comment, and indeed reminds us, in more ways than one, of the initiatory proceedings which occurred in connection with the late Pan-Electric scandal in our own country. However, the case was tried in court and judgment given (which we print in another column) annulling the patent. An analysis of the reasons upon which the decision of the Court is founded shows that the invention was admitted to be a most useful and meritorious one, and that its novelty was not necessarily impeached by any or all the numerous printed publications and paper patents put in by the defense for the purpose of showing it to have been old. The real difficulty was found in the vagueness and insufficiency of the patentees' specification, which failed to distinguish with sufficient clearness between what the patentees had done and that which was public property. We understand that the case is to be appealed, and it would seem as if there were at least an even chance of a decision favorable to the patentees. Whatever may be the ultimate fate of the British patent, it can have no legal bearing upon the status of the American patent for the Gaulard-Gibbs invention.

The opinion of Justice Kay in the Edison lamp case (which will also be found in another part of our present issue), cannot but be regarded as an exceedingly able one, both by reason of the extent and accuracy of the knowledge of the state of the art displayed in it, and of the unerring instinct by which the real issues of the case have been grasped and dealt with. The Edison-Swan Company went into court with a very strong presumption in their favor, arising, of course, from the circumstance that both the patents sued on, Edison's for the incandescent lamp and Sawyer & Man's method of treating filaments by heat in the presence of a hydro-carbon (known in England as the Chesebrough patent), had been twice sustained in an action brought against Woodhouse & Rawson. But the suit just terminated appears to have been defended with far more boldness, vigor and ability than the others, the efforts of the defendants being mainly directed to establish the inaccuracy and insufficiency of the specification, and to the inadmissability of the broad claim in view of the prior knowledge of the art, as evidenced by the work of Swan, Lane-Fox and other early laborers in the field. Beginning with a masterly analysis of the state of the art and of the voluminous testimony presented on both sides, — and it must be confessed, in the main, exceedingly well presented, —the Justice reaches the conclusion that the Edison patent is invalid, first, because he aims at an exclusive monopoly of all incandescent lamps with carbon filaments, a claim which the Justice says, "is far too wide, considering how little Edison had actually invented;" second, because the lamp described in the specification never became or could become a commercially successful one, and third, because the carbon described could not be made without much previous experimentation. There are other objections stated, but

we have enumerated the leading ones. The Justice also remarked, that if the same materials had been before the judges in the earlier case, he believed they would have reached his conclusion.

A careful examination of these cases, has but served to confirm our first impression, that the adverse result in both was due to precisely the same cause viz:—the utter failure of the solicitors who prepared the specifications to comprehend wherein the real invention consisted, and so to differentiate it properly from the prior work of others. Each ignorantly sought to claim the whole art, instead of the particular step in advance which had really been made, and in thus grasping at a shadow the substance has been permitted to fall to the ground.

In the same judgment, the Sawyer-Man or Chesebrough patent, which is controlled in Great Britain, by the Edison-Swan Company, and in the United States by the Consolidated Company, was fortunate enough to have its novelty and validity emphatically reaffirmed. We imagine it will be found somewhat difficult to compete successfully in the production of incandescent lamps without the employment of the hydro-carbon treatment, and hence the position of the Edison-Swan Company would seem to be a sufficiently secure one, notwithstanding the adverse result with the Edison patent. The British law does not permit the sale within the realm of goods made by a patented process, even though the process be worked outside the jurisdiction, and hence the holders of the Chesebrough patent are secured against foreign as well as home competition. It has been asserted, apparently by authority, that whatever result attended litigation in England respecting a patent, "*ergo*, a like result must follow in this country." It is hardly necessary to point out to the intelligent reader that this is a little doubtful, to say the least.

OVERHEAD WIRES IN NEW YORK.

The developments in the work of the Board of Electrical Control, since the appointment of Mr. Schuyler S. Wheeler as electrical expert some six weeks ago, indicate very clearly that the board and other departments of the municipal government are likely to find their hands full enough of work for some time to come, without building any more subways. The systematic inspection of overhead lines initiated by Mr. Wheeler, and still going forward, has already brought to official notice electrical atrocities that surprise even those who are familiar with the disgraceful aspect of electric lines in the crowded portions of the city. It is undoubtedly a fact that from the beginning of line construction in the city there has been absolutely no official supervision or restraint upon the work, carried on by various and sometimes conflicting companies and for a variety of purposes. The result is that inconveniencies and danger, to say nothing of the disfigurement of the city streets, are due much more to the execrable character and want of systematic plan of the existing network of city wires, than to the overhead system *per se*.

There is no doubt, as Mr. Wheeler says, that the wires must ultimately go underground; but much time must elapse before that work can be satisfactorily accomplished, and the obvious and pressing need now is the efficient prosecution of the work, so energetically begun by the experts' department of the Board of Electrical Control, to initiate and maintain something like electrical law and order among existing lines, a very large portion of which must remain in the air for some years to come, and to restrain or suppress the aerial freebooting that has gone on unchecked hitherto.

The following are a few specimens of the greater enormities reported by Mr. Wheeler:—Four lines of poles on one side of a street; pole, corner of Broadway and 25th street, carrying 20 electric light wires, of which 18 are "dead" and terminate at the pole; at the next pole three "dead" wires start; one wire from this pole shows 13 splices in a single stretch; a house in Stone street has twenty-five "dead" wires running from its roof; a heavy cable, two inches in diameter, extends over housetops and poles from No. 63 Broadway to Canal street and is entirely unused; a prominent telegraph company has a line of poles with cross-arms from the neighborhood of the bridge to 42d street with a single wire on them to maintain right of way.

At the end of July notices of about nine hundred violations of the rules of the board had been sent to the various electric companies of the city, of which one-third or more called for the removal of "dead" wires. Thus far little has been done by the companies in removing them. If the wires are not removed by the owners after a week's time a second notice is served, and at the same time the Bureau of Incumbrances of the Department of Public Works is notified. The bureau has thus far done nothing, the Commissioner of Public Works alleging that no appropriation applicable to removing poles and wires exists. The work of weeding out superfluous poles and wires is therefore in abeyance, except in the relatively few cases where the owners carry it out on notice. About fifty-five miles (measured by the ton) of "dead" wire has been removed by the Metropolitan Telegraph Co.

The Brush Electric Light Co. are reported to have followed out systematically all notices of violation of the rules sent to them, and have ordered a mile of eight conductor cable, to be placed in the subways for their arc light circuits. The United States Illuminating Co. seems disposed to resist the discipline of the Board of Electrical Control, and not only contests in the courts the orders of the board to place certain of its circuits in the subways, but is reported to have been very negligent of the notices of faults in their overhead wires.

In view of the intelligent guidance in its work which the board has now secured in the appointment of a competent expert—one who, through his experience in electric lighting, is acquainted with the difficulties of the situation as they present themselves to the lighting companies,—it seems unlikely that unreasonable requirements will be made, either as to the occupation of the subways, or in the more important matter, at this time—the proper regulation of overhead lines.

As our readers are aware, we are very far from believing that the subways thus far constructed or planned will afford a permanent solution of the city wires problem; but the best way to demonstrate their inadequacy is to try them fairly.

"TRYING IT ON THE DOG."

Mr. Harold P. Brown, Electrical Engineer, essayed, on Monday, July 30th, before the Board of Electrical Control and a number of electricians and reporters, to demonstrate his public assertions in respect to the extremely dangerous character of alternating currents, by means of some experiments on dogs; but the Society for the Prevention of Cruelty to Animals intervened, and stopped the proceedings after one good sized dog had perished. This animal indeed received his quietus from an alternating current, stated to be of 330 volts, after having been first subjected to shocks from an assortment of direct currents up to 1,000 volts, which are stated to have reduced his "ohmic" resistance from 15,300 at the start to 2,500 before the alternate current was applied—and which probably reduced his vitality in a corresponding or greater degree.

To say that one Newfoundland has died in vain for the cause of science is sufficient comment on the matter as it stands. Further remarks are left to our poet in another column.

UNDER the somewhat complacent caption "A Homeric Nod," an esteemed contemporary devotes over a column of editorial. in a recent number, to a very diverting apology for an insignificant error in a technical article that appeared in its columns several months ago, and which it refrained from correcting upon discovery immediately after, "in order to learn whether the error would be noted by its readers, serving both as a measure of their acumen and intelligence." Happily, the editor was not disappointed, numerous letters being received, kindly pointing out the inaccuracy as an unwonted and surprising aberration of the Homeric mind. In addition to its classical title, the editorial is furnished forth with quotations from Beecher, Gladstone, Dr. Johnson, and Horace (the latter thoughtfully translated into the vernacular of the untutored reader), and is not half-bad reading for summer weather. But why, O why, did the editor append a vague and general complaint of alleged prevalent uncredited appropriations from the columns of his journal on the part of contemporaries? Has his Homeric head set to nodding again? In view of his cribbing, a few months ago, of a very important document from another journal, printing it as his own, without credit, he will perhaps permit us to direct his attention to a couplet in homely English—to wit—

"Let them in houses made of glass who dwell
Forbear the flinty missile to propel."

WE regret that pressure upon our space prevents our printing the address of Professor Anthony on "Overhead Wires," delivered at the Electric Club, June 28. Electricians are accustomed to the conjunction of accurate knowledge and common sense displayed by Professor Anthony whenever he talks on electrical subjects, which qualities were not wanting on the occasion referred to. After pointing out the relatively small danger to the general public of electric wires, as compared with the ordinary risks of city life on the streets, the speaker said:—

The danger from overhead wires is by far the least of all the reasons for removing them. Linemen would still have to make new connections, and I am not sure that their danger would not be increased rather than diminished by putting the wires underground.

Incidentally, Professor Anthony caustically paid his respects to the gentlemen who, at a recent electrical convention, gravely stated that an escape on an arc light circuit robbed the field magnets of the dynamo and reduced its out-put, "preventing just so much current from passing back around the field magnets," assigning this as one of the difficulties of underground wires. The professor well remarked that it was not to be wondered at that the general public did not understand the problem, when a president of an electric lighting company tried to enlighten it after this fashion.

WE note that Professor Anthony reaches the conclusion expressed by the ELECTRICAL ENGINEER in October, 1-87, that nothing short of a system of tunnels, large enough to permit the passage through them of men and small trucks, will avail to overcome the inherent difficulties of providing satisfactory subways for general electrical distribution in large cities.

THE agreement upon Atlantic cable rates reached by the competing companies would seem to be a satisfactory close of the cable war, in regard both to the public and the cable companies. The 25 cent rate cannot fairly be complained of as unreasonable, and there can be no doubt that the 12 cent rate was unremunerative to the companies. A fair rate is essential to secure good service. The plucky behavior of the Commercial Cable Co. throughout the contest particularly merits public approval, especially their firm stand against an advance in rates to 50 cent r more per word.

EXTENSIVE preparations are making for the meeting of the National Electric Light Association, in New York, August 29, 30 and 31, at the Hotel Brunswick. Dr. Otto A. Moses, chairman of the executive committee, who is taking active charge of arrangements, may be addressed at 17 East 22d street, the house of the Electric Club.

THE continuation of Professor Holman's valuable "Discussion of the Precision of Measurements," is unavoidably deferred till our next issue.

THE electric light companies are not pursuing a sound policy. The loss of property by fire, personal injuries and death, all tend to create a prejudice against electric lighting which should never have been allowed to gain a foothold.—*N. Y. Corr. Industries.*

OBSERVATIONS.

THE watch controversy which for a space did fail, now trebly thundering swells the gale; and how to make watches non-magnetic is again receiving from the advocates of the various methods, a large assortment of widely varying answers. The poet tells us that "the sentinel stars *set their watch in the sky*;" and a reference to July "Observations" disclose the case of a man who buried his watch in a box of earth with the object of correcting the time of the delinquent. Unless he and the newspaper reporter are chargeable with a derived circuit from the main line of veracity, the experiment was successful and the object achieved. Such a method can, however, it is clear, have no extended application. According to an advertisement in a recent number of an electrical weekly journal, another system, nothing, by the way, like the earth cure, has received the support of "the leading *hirologists* of the world;" and what are homœpathic physicians and reporters as compared with "hirologists!"

* * *

INVENTIONS have played an important part in the electrical history of the United States, and instances are not infrequent of inventors having reaped a financial reward. It is true, however, that there is one invention which not in itself electrical, has been associated with about every department of electrical application, which has perhaps been used more than any other, and which yet has never paid its inventor a dollar's profit. This is the "climbers" or "spurs" used by all linemen in climbing poles, and was invented by Mr. Charles T. Smith.

This thought was suggested to the observer, as he turned over some old correspondence and came across the name of Mr. Smith, in a letter written to him by the late Henry O'Reilly. The following passage occurs in the letter: "I must specially mention your climbing spurs, marks of which are shown on telegraph poles all over the land; by which "spurs" the hardy telegraph builders and repairers can readily ascend the posts to arrange and repair the wires and insulators, freed from the annoyance of ladders and other contrivances, commonly used before you invented this valuable aid for builders and repairers of telegraph lines. Your climbing spurs have, besides greatly promoting the convenience of all concerned, saved annually hundreds of thousands of dollars to the telegraph companies throughout the land." Probably no reader of these Observations will feel inclined to gainsay Mr. O'Reilly's opinion; on the contrary, it is certain that any one who has worn the climbers long enough to "win his spurs," will be disposed to endorse it fully. Suppose they were for the first time produced now; it is safe to say there would be at least 10 applicants for a patent, a four year's interference, and 40 prior inventors.

* * *

MENTION has been made in previous Observations of wondrous inventions in electro-therapeutics. Hat batteries, electro-medical spectacles, and other appliances, have helped to fill the records of the Patent Office, and perhaps also the pockets of the patentees.

"This last quarter of the 19th century," as the pulpit orators call the current period, has been prolific in electrical devices of all kinds, including those of a medical nature. But the creative minds of the earlier ages of the world were not content to ignore entirely the manifestations of the force which was—and is and in all likelihood, ever shall be—unknown, and they accordingly tried to make use of it in the cure of diseases.

All the Year Round, of a comparatively late issue, reproduces some of the wonderful recipes of Pliny the Elder, who was also quite possibly a Benjamin Franklin the Elder. It cannot be proved that he enticed the lightning from the skies, but he told how to make good use of it after its descent. Listen, all ye who suffer with toothache. "If one bite off a piece of some tree that hath been blasted with lightning, provided always that he hold his hands behind him in so doing, the said piece of wood will take away the toothache." Caius Plinius Secundus was somewhat of a philosopher, but he evidently did not believe in enduring the toothache patiently.

ARTICLES.

SPRAGUE MOTOR CURVES.

BY FRANK P. COX, B. S.

THE method used in obtaining these curves is known as Hopkinson's method, and was fully described in *The Electrical Engineer* January and February, 1887. As that article may be somewhat too abstrusely mathematical for many practical electricians, and as this paper is intended to be a reliable guide to such electricians in their work, all the operations will be fully described.

Excepting the dimensions of the machine, only one measurement is necessary. That is to determine the value of the constant ν. This value is the ratio of the total lines of force through the field magnets to the useful lines through the armature. I have described in the last number of this journal the method of finding an expression for these lines. In this case $\nu = 1.76$.

It is also necessary to have a curve representing the relation between the magnetizing force H and the permeability, μ for wrought iron and a similar curve for cast iron.

Hopkinson gives curves for cast and for wrought iron, showing the relation between B, the magnetization and H. From those curves several values of μ have been worked out and the following curves constructed:—

Cast iron. μ	H	Wrought iron. μ
400	10	1130
270	20	700
207	30	495
168	40	384
140	50	315
121	60	268
108	70	233
98	80	208
90	90	188
84	100	170
71	125	135
61	150	117
51	200	92

The method of using this curve will be described later. We must now make use of Hopkinson's formula to find the required magnetizing forces.

The formula is

$$4\pi n c = l_1 f\left(\frac{I}{A_1}\right) + 2l\frac{I}{A} + l f\left(\frac{\nu I}{A}\right) + 2l f\left(\frac{I}{A}\right)$$

Where

"n" is the number of turns on the field,

"c" the current in C. G. S. units,

"I" represents the induction and is the quantity we wish to find the value of.

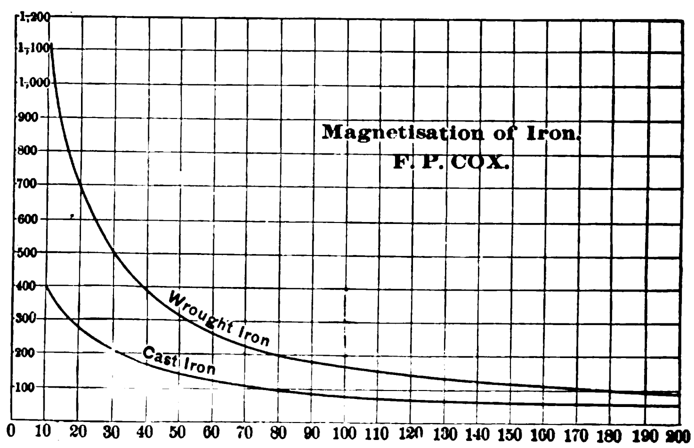
"l_1" is the length of the lines of force in the armature, and is slightly greater than the shortest distance between the pole-pieces. It is in this case 10. c.m.

"A_1" is the cross-section of the iron in the armature, and is .9 of the total cross-section in a horizontal plane; 10% being allowed for lamination. A_1 is 224 sq. cm.

"l" is the perpendicular distance between the faces of pole-pieces and the armature core. l is .7 cm.

"A_2." This is the area of the face of pole-piece, + 13%, to allow for dissipation of field. It is 286 sq. cm.

"l_2" is the length of lines of force in the field, that is, the length of the field core. It is 16.8 cm.



"A_3" is the area of the field cores, and since there are two magnetic circuits in parallel, twice the area of one magnet limb will have to be used. A_3 is 153.4 sq. cm.

"l_3" is the length of lines of force in pole-piece. This cannot be measured *exactly*, but it is approximately 21 cm.

"A_4." As in case of A_3, the mean area of cross-section will have to be doubled, giving 198 sq. cm.

"ν." As stated before, ν is 1.76.

The formula now becomes

$$4\pi n c = 10 f\left(\frac{I}{224}\right) + 1.4\frac{I}{286} + 16.8 f\left(\frac{1.76 I}{153.4}\right) + 42 f\left(\frac{I}{198}\right).$$

It is now necessary to substitute for the functions their values, and to divide the equation up into its parts. The first term represents the force required for the armature, the second that for the air space, the third for the field, and the fourth for the pole-pieces. In the equation the functions may be expressed by multiplying the term by $\frac{1}{\mu}$. Now, to obtain the curve for the armature we vary the magnetizing force $x = \frac{10\,I}{224\,\mu}$ and for the different assumed values of x work out the value of I. The curve is then plotted with these values of x and I. In a similar manner the curves for the other parts are constructed. The air space will in every case be a straight line. Before discussing the characteristic curve it may be well to construct the other curves, as the characteristic is taken directly from them.

We have for the armature

$$x = \frac{10\,I}{224\,\mu} \text{ or } I = \frac{224}{10}\mu x$$

For the air space,

$$x = \frac{1.4\,I}{286} \text{ or } I = \frac{286}{1.4}x$$

For the field,

$$x = \frac{29.6\ I}{153.4\ \mu} \text{ or } I = \frac{153.4}{29.6}\ \mu x$$

For the pole-pieces,

$$x = \frac{42\ I}{198\ \mu} \text{ or } I = \frac{198}{42}\ \mu x$$

Now, when we give to x different values, the value of I for each one is easily worked out, since μ depends directly upon x, and its value can be obtained as follows:—Since x represents the total magnetizing force, we must divide by the length of the line of force to obtain the magnetizing force per unit length. Now having obtained this value we look upon the magnetization curve, which is plotted in terms of μ and magnetizing forces per unit length. This curve gives us the value of μ for this value of x, and having this the value of I follows directly. The following tables give values required in the construction of the curves:—

ARMATURE.

$\frac{x}{l_1}$	x	μ	I
5	50	1550	1,786,000
10	100	1130	2,581,200
30	300	495	3,326,400
50	500	315	3,528,000
80	800	208	3,727,360
100	1000	170	3,808,000

AIR SPACES.

x	I
1000	204300
2000	408600
3000	612900
4000	817200

FIELD.

$\frac{x}{l_3}$	x	μ	I
5.95	100	1410	730,380
17.85	300	765	1,188,810
29.75	500	497	1,287,230
47. 6	800	328	1,359,232
59. 5	1000	270	1,398,600
89.25	1500	189	1,468,530
119.	2000	143	1,481,480

POLE-PIECES.

$\frac{x}{2\,l_5}$	x	μ	I
7.14	300	442	624,546
11.9	500	370	871,350
19.04	800	280	1,055,040
23.8	1000	242	1,139,820
47.6	2000	146	1,375,320
71.4	3000	104	1,469,520

CONSTRUCTION OF CHARACTERISTIC.

From any point on the air space line lay off an abscissa equal to the sum of the abscissas of points in the curves for armature, field and pole-piece, whose ordinates are equal to the ordinate of the selected point in the air space line. This point will be a point in the characteristic curve. Any number of such points can be similarly obtained and the curve drawn through them. This construction does not take into account the effect of the current in the armature, as in this particular machine its effect is practically zero.

We have now all the data required to construct any size dynamo or motor of this type. Suppose, for instance, we wish to build a dynamo of this type with a given number of armature coils to give a certain potential at a given speed of rotation.

On the characteristic take "A" before the curve becomes too nearly horizontal. The induction for this point is 1,150,000, and the magnetizing force 7000 C. G. S. units. The potential this dynamo would develop at the given speed is given by the formula.

$$E = \frac{n\,r\,I}{100\,000\,000}$$

where

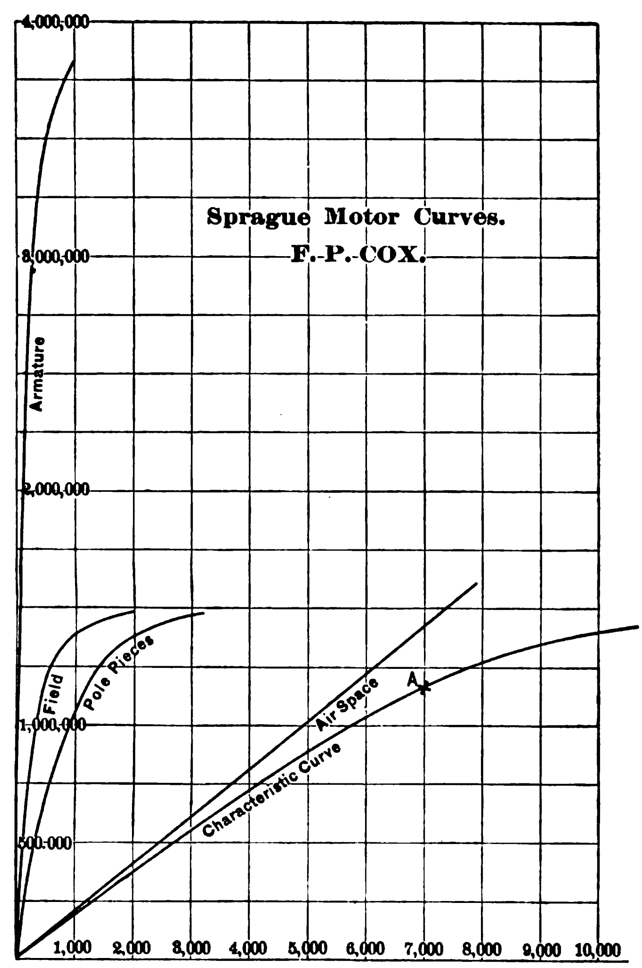
E = volts developed

n = number of armature coils.

r = revolutions per second.

I = induction.

Now this value is perhaps too small, and a larger machine will be required. Silvanus Thompson tells us that "if the linear dimensions of a dynamo be increased n times its output is increased n^3 times." This rule is only approximately true; so that when we select n so that $n^3 E$ = the required potential and construct a new set of curves, we shall find that they are not exactly right.



From this new characteristic we calculate the volts which would be developed at the stated speed, and find that it is either a little too great or small. Some small changes will have to be made in the different parts, until, by successive approximation the required potential is obtained. It is now necessary to know how strong to make the field. The magnetizing force required to produce this induction is expressed by

$$H = 4\,\pi\,n\,c,$$

or

$$n\,c = \frac{H}{4\,\pi};$$

but this is expressed in C. G. S. units, and will have to be multiplied by 10 to be expressed in units in daily use, giving the required ampere turns $= \frac{5\,H}{2\,\pi}$. A few words

upon size of wire to use may not be out of place. We know the potential at the terminals and can approximate to the external resistance, and, therefore, as to the current which will flow through the armature, and thus calculate the size wire required from the following rule. Wires to 2 mm. diameter can safely carry five to six amperes per sq. mm., and wires of 5 mm. diameter can safely carry three amperes per sq. mm. For the field, if it is a shunt machine, its resistance should be at least 364 times that of the armature, so that we can choose any resistance greater than this, only remembering that it must be the resistance of wire of proper size to carry the current, and of such length as to give the correct number of turns.

PHYSICS IN PUBLIC SCHOOLS.

BY C. J. H. WOODBURY.

THAT our public school system should perform all that is required of it demands that the instruction, at least in the more densely populated portions of the country, should extend beyond the mere rudiments of letters and figures, and be broad enough to include a training in accurate observation and correct reasoning. It should include a knowledge of the elements of business and of science in their applications to every-day life; and in this connection it is necessary that the principles of electricity should be accurately taught in our public schools.

By the luck of nomination and the accident of election, I have been a member of a school board for several years, and not long ago there was occasion to examine candidates for teachers' positions. There was an English high school to be started, and at least one prospective vacancy in the classical high school to be filled, and a number in the grammar schools, all of which were positions where the teacher should have some knowledge of modern science as a matter of general intelligence for guiding the miscellaneous reading, or directing the attention or answering the questions of scholars upon technical subjects, even if they were not included strictly in the course of studies.

These teachers' examinations are in writing, and one course of questions included a few interrogations upon topics of physics and chemistry. The only one concerning electricity was, "Explain the principle of the Bell Telephone."

The question was put in this manner, not merely as an examination upon the principles sought for in the question, but because on account of the extended use of the instrument, the large amount of space devoted to it in the newspapers, and the controversies upon its invention; the answers would certainly furnish an indication of the habits of observation and of general newspaper reading on the part of the candidates.

Persons frequently gather a collection of peculiar answers given to questions by school children, as examples of incongruous thought; but these candidates for teachers were, with two exceptions, graduates from high schools of excellent repute, and the majority of them had received instruction in the normal schools. Of the two who were not graduates of high schools each had passed through one of two leading academies in New England. Therefore the answers did not represent the immature thoughts of school children, heedlessly catching on to a few words without realizing their significance, but were the answers of a number of young ladies who had received the benefits of the best public school instruction given in the oldest of our New England states.

The answers of those who attempted any reply to the question were as follows:—

1. The telephone is upon that principle that sound may be transmitted a great distance along a wire.

2. Sound having a medium to carry it will travel.

3. It is carried on by that mighty power, electricity. We ring an electric bell. When we speak we hold a cup or handle to our mouth in order that the sound may be concentrated and pass with more force along the wire. The person who is listening holds it to his ear in order that the sound may be more concentrated and pass with more force to his ears. The principle is electricity being able to transmit sounds a very great distance by connection of wire.

4. The principle of the Bell telephone is based first upon electricity.

5. The principle of the Bell telephone is the application of electricity, by means of a battery, to the conveyance of sound by waves caused by the expansion and contraction of air. Before that was invented, something that corresponded to it, for very short distances, was used. It consisted of a tube with a mouthpiece at both ends, across which were stretched membranes. The one at the side where the speaking is, vibrates; the vibrations are continued through the tube to the other membrane, and to the listener there as sounds. This could be used only for short distances because the vibrations are weak, and for long distances electricity was applied to make them stronger, and iron plates were used instead of membranes.

6. The telephone consists principally of a thin steel plate which is vibrated by a permanent magnet placed just back of it. The voice causes waves of condensation and rarefaction to undulate through the wires, and touching the magnet, causes the thin plate to vibrate with waves of the same kind. Thus the waves being of the same kind as those of the other end of the wires, the sound is reproduced, and one listening, can plainly hear what is spoken at the other end of the apparatus.

7. The voice, striking against the electro-magnet of the speaking tube, sets the magnet into vibration. These vibrations are transmitted along the wire of the tube, and there to the tube at the other end of the connection. The sound waves here strike upon the membrane of the tube and thus reach the ear.

8. The Bell telephone has a small disc which is over a permanent magnet. This disc is kept in place by a cup-shaped cover to which the mouth is applied in sending a message. There are two posts connected with the permanent magnet; one goes into the ground, and the other is all connected with the receiver at the distant station.

9. By means of a telephone, communication can be carried on by articulation. The Bell telephone consists of a small wooden arrangement. This is attached to a wall, and from this wires are extended to the place of communication. There is an opening for the mouth and also a small piece connected to the instrument by a cord to hold it to the ear.

The sounds are transmitted in waves along the wire, and coming in contact with the air strike against the ear drum, and are transmitted through the chain of bones to the openings on the inside, and thence by the optic nerves to the brain.

10. The Bell telephone consists of an instrument which is held to the mouth to speak through. It contains a platinum disc which is set in vibration by the sound waves produced by the voice. It vibrates against a magnet to which are connected two magnets which wind around two screw-cups and then pass through the instrument to the distant station. Over the platinum disc is placed a cup to which the mouth is applied.

It will be noted that none of the answers referred to the transmitter or to any of the accessories of the telephone, that none of them use the widely known expression that its purpose is "for the electrical transmission of speech." In short, they were, collectively, a vague, inaccurate, and unsatisfactory attempt at jumbling words together to express an indefinite idea; and all of them disregarded the request to explain the *principle* of the telephone, and substituted sorry efforts, with all the vagueness of ignorance, to recall disjointed phraseology from the text books.

Another question asked for a definition of five of the following words,—element, specific gravity, force, inertia, unit of heat, unit of work, centre of gravity. The limitations of error very naturally prevented the answers to these interrogatories from being worse than those about the telephone. Force was defined as follows :—

1. Force is a push and a pull.
2. Force is the attraction which one body has for another.
3. Force is anything which changes or tends to change the nature of a substance.
4. Force is anything which occasions a change in a substance.
5. Force is a power by which matter is governed.
6. Force is the propelling movement a body possesses.
7. Force is the propelling movement a body possesses.
8. Force is anything which causes a change in a substance.
9. Force is that which acts upon an object to produce a certain result.

Inertia was defined as,—

1. That phenomena by which a displaced body tends to return to its former position.
2. That power which keeps a moving substance moving and a stationary substance stationary.
3. That which tends to make a body keep its position or remain in a state of rest.
4. Inertia is that when a body is at rest it will remain at rest, when a body is in motion it will continue in motion.
5. Signifies a body at rest.
6. The obstruction which stops a moving body.
7. Inertia is the rate of motion.
8. Inertia is one of the universal properties of matter which a body possesses unless acted upon by some repelling force.
9. Inertia is the state of rest of a body.
10. Inertia is the quality of passiveness.
11. Inertia is that force by which a body may be moved from one place to another.

Unit of heat was defined thus :

1. Heat required to raise the mercury in a glass tube to the zero point.
2. Amount of heat required to heat a certain body.
3. Average time in which a body becomes heated.
4. The standard from which all heat and forces of heat are computed.
5. The regulation made by which to reckon a decrease or an increase.

The questions were framed after a perusal of the text books of physics used by a majority of these applicants ; and the questions were confined to subjects accurately and clearly treated in several of these books, and it could not be truly alleged that the questions led into subjects foreign to the instruction given in the high and the normal schools.

Where shall the responsibility be laid for this sort of thing? Certainly not upon the candidates, who were manifestly unusually bright scholars on other topics ; nor is there any reason to impugn the intelligence of their teachers. Both teachers and pupils were from a too extended range of territory and under a too wide a diversity of environment to admit that the results could be ascribed to any influences purely local in character ; and the results must have been the fault of methods of instruction.

The public school system is so great, reaching to almost every household, and forming a portion of almost every life, that any criticism of its policy nearly approaches to the "impossible indictment of a nation."

It is frequently remarked by high school teachers that girls are slow in physics and good in chemistry, in comparison with boys. The reason, I believe, to be primarily due to the lack of laboratory practice and demonstration, which is a part of the natural experience of the boys in the use of the jack-knife and in familiarity with all sorts of mechanical processes,—an experience often obtained at the expense of a reputation for meddlesomeness ; while the tastes and opportunities of the girls do not offer such chances for learning how to think with their fingers. And yet we do not see that difference in the results of instruction in chemistry, because excellence in that study is the result of memory rather than that of other faculties. It is evident that efficient instruction in physics can only be carried on in connection with laboratories, and that laboratory practice which proceeds concurrent with the studies in the books.

SOME ELECTRIC PROPERTIES AND USES OF CARBON.

BY L. A. BEST.

(Brooklyn Central Grammar School.)

CARBON has become a necessary material in nearly all electrical appliances, and a study of this substance well repays the electrician. He should at least be familiar with its action under different conditions, as changes of temperature, etc. Early last fall I began a series of observations on carbon which was continued until March of this year ; and, while some old results were verified, some others were arrived at that are interesting and useful.

The experiments were divided into four classes:

1st. Methods of determining and the determination of the co-efficient of resistance of carbon due to change of temperature.

2d. The application of the fact that the law of change in carbon is the opposite to that of metals in the construction of a compensated standard ohm.

3d. The investigation of the question, "Does change of pressure effect the resistance of carbon ?"

4th. The effect of change of contacts on the resistance of carbon.

THE LAW OF RESISTANCE.

For the first series several pieces of apparatus were devised, the best of which will be described:

Figure 1 represents the elevation of one form of apparatus as used. A Carré pencil of carbon, K (figure 2), was electro-copper-plated at the ends, A A, and these plated ends were soldered to copper bands, C C, which were fastened (as indicated in figures 2 and 3) to a piece of plate glass, G. Leaders of copper were soldered to these bands, and the whole, with a thermometer, was inclosed in a test tube, T T (figure 1), the bulb of the thermometer being as near the middle of the carbon as possible. The test tube was corked tightly, the leaders and thermometer passing through the cork, the tight corking preventing currents of air. This apparatus was placed in a vessel as indicated in figure 1. W represents a block of wood in which the test tube rests, and B B are braces to hold the tube in place. The leaders L L were connected with an Elliott Bros. dial bridge, and readings were taken for temperatures ranging from 0° C to 100° C. The apparatus being first packed in ice and afterwards heated gradually to the boiling point. Figure 3 represents a method of mounting adopted to prevent any possible effects caused by the carbon being rigidly mounted, as in figures 1 and 2. A copper cup, A′, soldered to the lower band C, was filled with mercury, and the lower end of the carbon dipping in this furnished amalgamated connections and allowed the carbon perfect freedom for expansion and contraction. *The two methods of mounting gave precisely the same results.* The resistance of the apparatus and leaders was determined by connecting the copper bands C C with a heavy copper rod.

Figure 4 represents another form of apparatus used for investigating the effects of high temperatures. The carbon K was plated as before, and fine copper wires were laid lengthwise along the plated parts and bound fast ; these ends were again plated with the wires, and unvarying connections were thus obtained. The carbon was wound with

asbestos paper, and a piece of pure platinum wire was wound around the outside, copper terminals *m m* being fused to the platinum. This apparatus was placed in a ings were taken as high as 1000° C. The platinum was used as a pyrometer, and the magnesium carbonate was used to prevent oxidation of the carbon by the intense

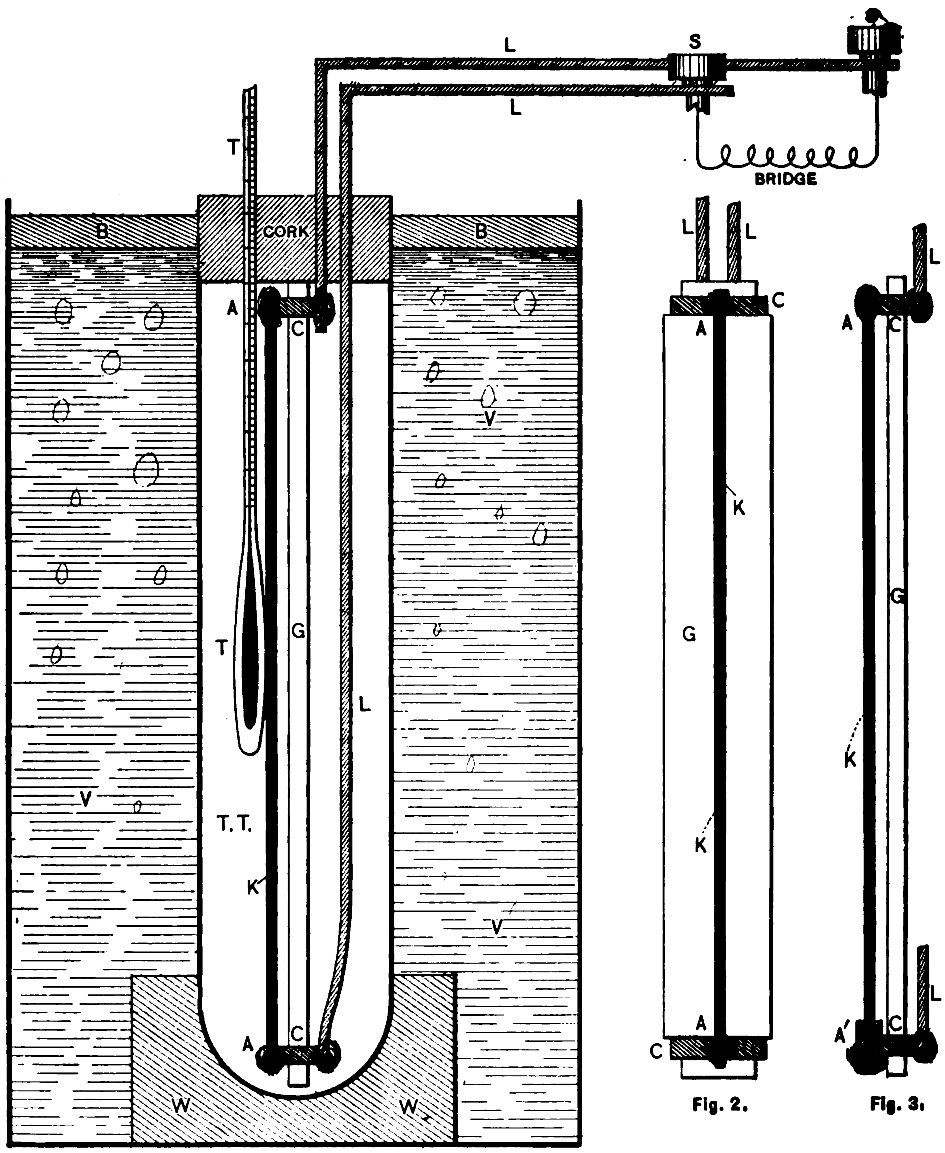


Fig. 2. Fig. 3.

Fig. 1.

Apparatus to Determine Coefficient of Resistance of Carbon.

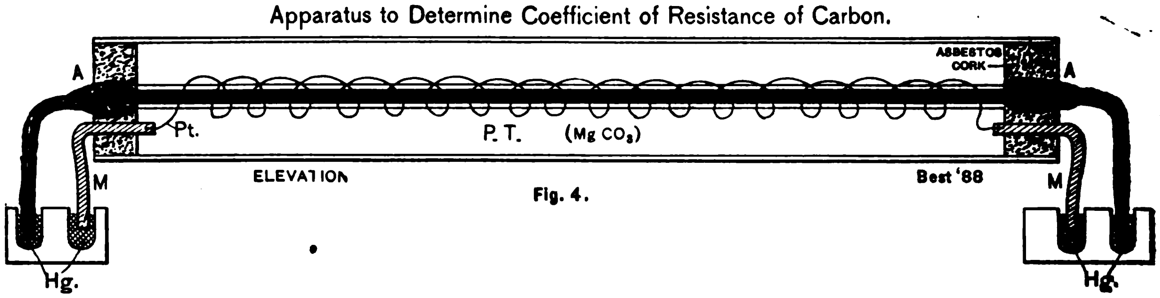


Fig. 4.

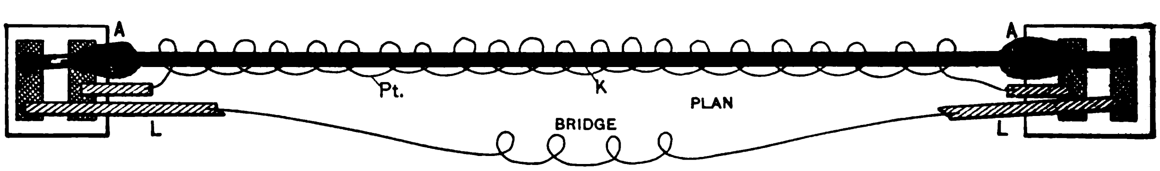


Fig. 5.

porcelain tube filled with magnesium carbonate and corked with asbestos. The tube was placed on a gas furnace, the terminals all furnishing unvarying connections, and read- heat, the $Mg\,C\,O_3$ separating (before reaching the oxidizing point of carbon) into $Mg\ O$ (a non-conductor) and $C\,O$, the latter making an atmosphere in which combustion is im-

possible. From the law of change in platinum the law for carbon may easily be determined. The platinum being wound around the carbon would be of the same temperature, care being taken to keep the apparatus at the temperature required until no change occurred in either the platinum or carbon. Figure 5 gives the plan of the apparatus. Readings were in all cases taken with direct and reversed currents in order to correct for thermo-currents. For low temperatures (0° to 200°) I used a modification of this apparatus with the best results. A thermometer was substituted for the platinum; the carbon was placed in a small glass tube, and the whole placed in a porcelain tube filled with fine sand. Temperatures were easily regulated with this apparatus.

A large number of Carré pencils were experimented upon, and it was found that no two had the same law, the rate of decrease in resistance from 0° C to 100° C varying from 2% to 4%, the mean being very near 3%. I give below the results obtained with one pencil, observations being taken for both increasing and decreasing temperatures to correct any errors resulting from slowness of action of the pencil in reaching a certain temperature.

TABLE I.

Table showing variation of resistance of carbon with change of temperature.

Rising temperatures. Temperature.	Resistance.	Falling temperatures. Temperature.	Resistance.
°		°	
14.8 C	1.8572 ohms	96.6 C	1.8213 ohms.
24.8	1.8532 "	86.4	1.8258 "
35.4	1.8485 "	76.4	1.8301 "
45.1	1.8440 "	65.2	1.8350 "
55.2	1.8394 "	56.2	1.8388 "
64.7	1.8353 "	45.6	1.8439 "
75.8	1.8306 "	36.0	1.8480 "
86.2	1.8260 "	25.3	1.8524 "
96.6	1.8213 "	15.5	1.8570 "

In plotting this series of observations it is easily seen that for low temperatures the law of decrease is constant. The above results give a decrease of 2.38% per 100° Centigrade. Other pencils gave .025, .0255, .035, .04, .03, decrease per 100°. This variation is probably due to different densities of carbons, impurities, etc., etc.

Several carbons were carried through the second apparatus for high temperatures, but on experimenting with the platinum used, I found that it did not follow the law as determined by Matthiessen. I found that each piece of platinum used would have to have its law determined independently. Until the law of my pyrometer is determined I cannot make use of my results.

THE COMPENSATED STANDARD OHM.

Making use of the peculiar property of carbon, *i. e.*, the property of decreasing in resistance with increase of temperature, I constructed a standard of resistance by compensation with copper in parallel circuit, the increase of resistance in copper due to increase of temperature just balancing the decrease of resistance in the carbon due to the same cause, thus giving a constant resistance for varying temperature.

Any one who has tried to make corrections for temperature in a bridge or other apparatus knows how difficult it is to keep a B. A. standard, as at present constructed, at the temperature which gives its correct reading; and he can appreciate the utility of a standard, whether it measure an exact ohm or not, which is *perfectly* constant for all temperatures.

This simple contrivance can be used not alone for slight variations that occur in the temperature of a laboratory during a series of observations, but for variations covering a range of 150° Centigrade, with perfect success, and it is vastly superior to the expensive and *variable* standards now in use.

If a standard ohm is to be constructed, the formula giving the proportions of carbon and compensating metal is deduced as follows:

Let μ be the coefficient of carbon, and ν that of the compensating metal; let r be the necessary resistance of the carbon at 0°, r^1 that of the metal; then from a law of parallel circuits,

$$\frac{1}{r_0} + \frac{1}{r_0^1} = 1 \qquad (1)$$

$$\frac{1}{(1-\mu)\,r_0} + \frac{1}{(1+\nu)\,r'_0} = 1 \qquad (2)$$

from (1)

$$\frac{1}{(1+\nu)\,r_0} + \frac{1}{(1+\nu)\,r'_0} = \frac{1}{1+\nu} \qquad (3)$$

from (3) and (2)

$$\frac{1}{(1-\mu)\,r_0} - \frac{1}{(1+\nu)\,r_0} = 1 - \frac{1}{1+\nu} \qquad (4)$$

or

$$\nu + \mu = \nu\,(1-\mu)\,r_0$$

from which

$$r_0 = \frac{\nu+\mu}{\nu(1-\mu)}$$

If a standard of n ohms were wanted the necessary resistance of the carbon at 0° C would be

$$\frac{n\,(\nu+\mu)}{\nu\,(1-\mu)}.$$

Although the law for resistance of metals is

$$R_t = R_0\,(1 + \alpha\,t + \beta\,t^2)$$

and for carbon

$$R_t^1 = R'_0\,(1 - \alpha'\,t \pm \beta^1\,t^2),$$

I have considered only the coefficients α and α', as practically the others may be omitted for temperatures below 200°, the variation of both carbon and metals for that range being virtually constant.

As an illustration of the above, a pencil whose coefficient was found to be .03 was compensated with copper whose coefficient was assumed to be .388 — *i. e.*, $\mu = .03$, $\nu = .388$. Applying the formula, the amount of resistance that the carbon at 0° must offer is

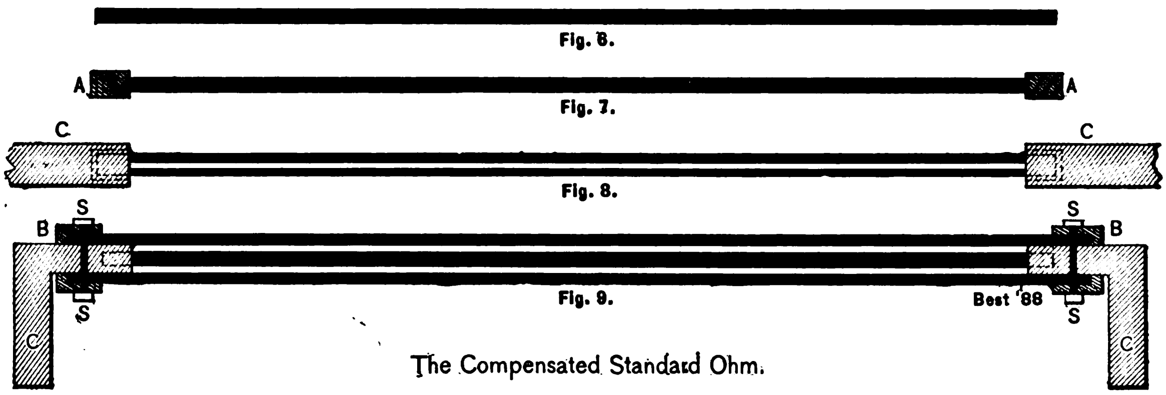
$$r_0 = \frac{.388 + .03}{.388\,(1 - .03)} = 1.11 \text{ ohm.}$$

And since the carbon was measured at 15° C, allowance at the rate of .03 decrease for 100° was made, which gave $r_{15} = 1.1056$ ohms. If a standard of 10 ohms were wanted 11.056 ohms would be cut off instead, which would be plated to give a resistance of 10 ohms.

In preparing a standard ohm, I first determined its law of resistance, using a pencil of several ohms resistance to determine the coefficient; then the formula for copper and the carbon was applied, the necessary length of carbon to give the required standard being computed. A piece about 8 mm. longer than the computed length was cut off and plated at the ends until the intervening strip offered the required resistance (figures 6 and 7); with a little care this can be very accurately done, when all that is necessary to complete the pencil is to plate it until it offers a resistance of just one ohm. This was done by varnishing the rod, leaving a strip about-one half mm. wide from one plated end to the other free from varnish, and then immersing the pencil in the bath and plating until the required resistance was reached. If too much copper were added, it could be removed by careful scraping or by suspending the pencil on the other pole of the cell. A few trials will give a perfect ohm. After compensating, the plated ends were soldered into the ends of copper rods, c c (figure 8), and the pencil was given a heavy coat of varnish. If the pen-

oil were to be preserved it could be mounted as indicated in figure 9. The rod, as shown in figure 8, is inserted in a hard rubber tube whose inner bore is the same as the copper terminals, the tube being two cm. longer than the carbon; brass caps, B B, are then fitted over the ends of the tube, the copper leaders projecting through the caps; the caps, tube and terminals are drilled through at S S, and secured by a strong rivet at each end; the terminals are then bent as indicated in the figure, and we have a perfect available standard. All air may be excluded by gluing the caps on and by soldering the ends where the terminals project through the caps.

One ohm mounted hastily did not vary .003 in 150° C, while a B. A. standard varied as much in 5°. Another run through about 100° C slowly, did not show any variation whatever. I found that on account of copper accommodating itself to any temperature more readily than carbon, being a better conductor of heat, that *sudden* variations of temperature caused temporary variations in the standard; but this disappeared as soon as the carbon reached the same temperature as the copper. But for practical use in the laboratory, with slowly changing temperatures, the apparatus is perfect in its action, and there is no doubt that it can be of great service to many who wish to make accurate measurements.



The Compensated Standard Ohm.

PRESSURE AND CONTACTS.

For investigating the change in resistance offered by carbon under varying pressure, I devised two pieces of apparatus, and obtained exactly similar results from both; the observations proving conclusively that a change of pressure alone on carbon,—the contacts remaining unchanged,—*had no effect on its resistance.*

In one apparatus used for this investigation the ends of a Carré pencil were plated as before, and copper terminals soldered to the plated ends; the rod as prepared was placed in a glass tube, set up vertically, and weights were applied; the terminals being connected with the bridge, *no visible change occurred* in the resistance, although a pressure equivalent to 300 atmospheres was placed on the carbon before it broke by buckling. Several carbons were tested in this way, but invariably with the same result.

Thinking that possibly the connections might not be

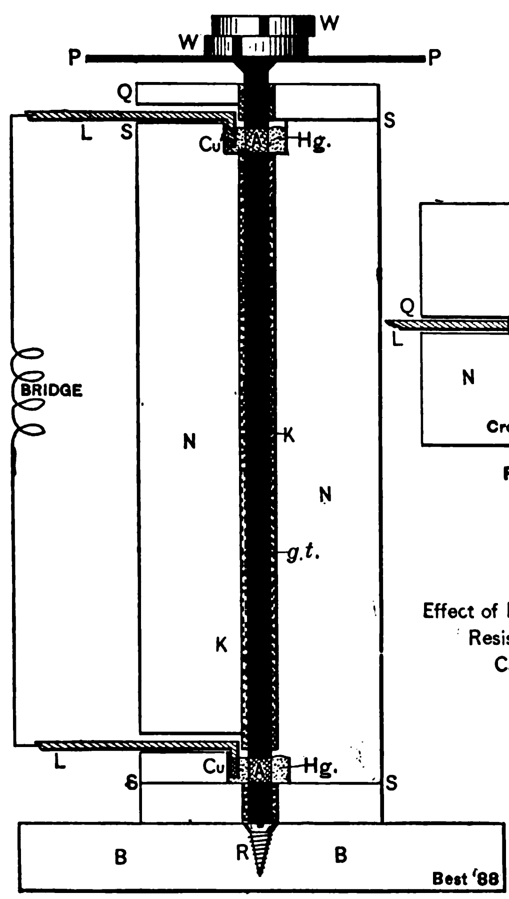


Fig. 10.

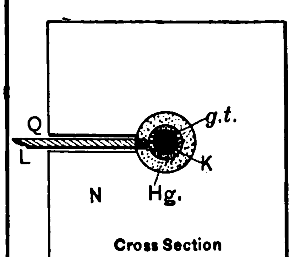


Fig. 11.

Effect of Pressure upon Resistance of Carbon.

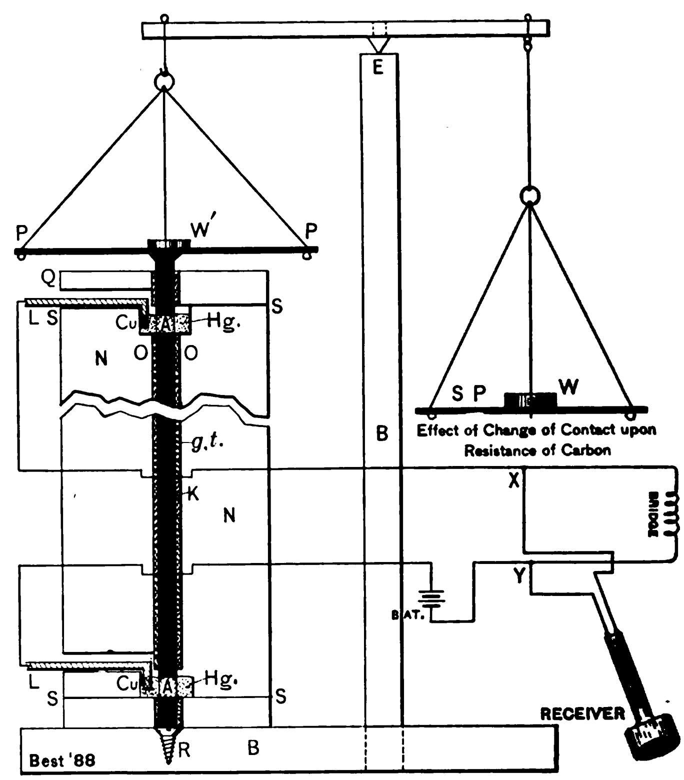


Fig. 12.

invariable, I devised the second apparatus as illustrated in figures 10 and 11. The carbon K had rings of copper plated around it at A A; a block of wood, N N, was bored through, so that a glass tube, in which the carbon just fitted, could be inserted, snugly fitting. The block was sawed through at S S, and copper cups, *cu cu*, inserted so that when the ends cut off were replaced and glued fast the cups would surround the plated portions of the pencil. Holes in the bottoms of the cups the size of the carbon allowed it to pass through. Holes were bored at Q to allow leaders to be inserted; the cups being filled with mercury gave amalgamated, unvarying connections. A plate, P P, soldered to the upper plated end of the carbon is for weights. Here, as in the other case, no appreciable change occurred in the resistance of the carbon, although pressure equivalent to 450 atmospheres was placed on the pencil. If the weights were suddenly removed no change occurred.

Mistrusting that variation in resistance of carbon usually attributed to *pressure* was simply due to variation of connections, I used this apparatus to investigate the question. The carbon was broken at O, figure 12; the weight of the plate P P and carbon from the plate to O was balanced by a scale pan and weight, W, as illustrated. The contact at O when the contact was good. The ordinates decreased very rapidly at first, but more slowly afterwards; in fact, if the rods barely touch at O, a fly walking across the plate P P makes an appreciable difference in the resistance, thus causing a variation in the current passing through the circuit; and if a telephone receiver be connected in place of the bridge, the fly may be heard to walk.

A carbon, whose resistance before breaking was 6.5 ohms, gave the following results, the weights being adjusted so that the resistance was just 20 ohms:

TABLE II.

SHOWING THE EFFECTS OF CHANGE OF CONTACT ON THE RESISTANCE OF CARBON.

Weights (x.)	Resistances (y.)
.125 gram.	15.356 ohms.
.25 "	12.166 "
.5 "	10.043 "
.75 "	9.368 "
1.0 "	8.746 "
1.5 "	8.385 "
2.0 "	8.005 "
3.0 "	7.724 "
4.0 "	7.542 "

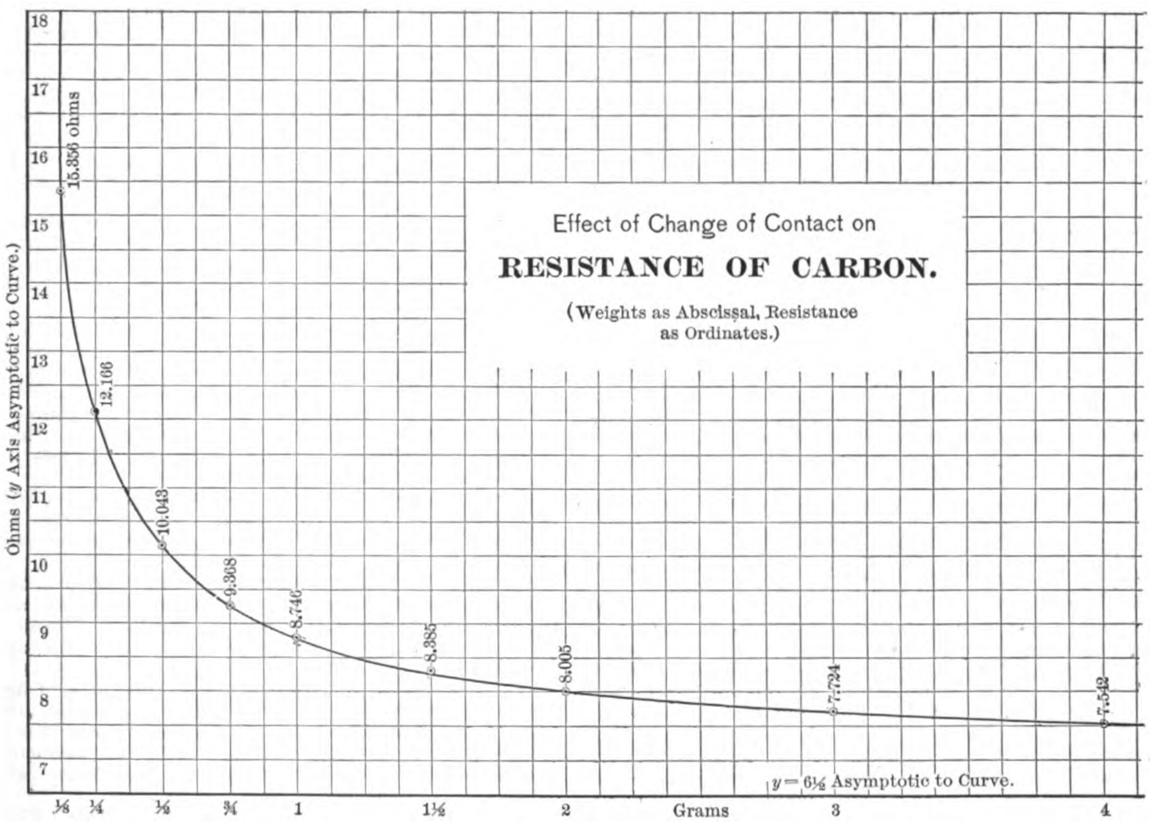


Fig. 13.

could be varied at will by weights on P P, while the other connections at A A remained invariable. It was found that the resistance varied from infinity, when the pieces were separated at O, to nearly the resistance offered by the pencil before it was broken; the resistance approaching the original resistance of the carbon as a limit as the weight on P P was increased. If x denotes weights and y resistances, the curve illustrating the changes would have as asymptotes $x = o$ and $y = R$ (R being the resistance of the carbon before it was broken). The experiment proved conclusively that change of resistance usually attributed to pressure, causing change of state, is due entirely to change of contact, as would naturally be expected. These results agree with those of Professor Siemens.

It was found that very small weights at P P, when the contact at O was almost imperceptible, had much greater effect on the resistance than a heavier weight applied

The curve is shown in figure 13; the weight, with resistance of 20 ohms, was estimated to be .1 gram. If the weights were removed, it was noticed that the carbon did not regain its former resistance, there being a sudden recovery to a certain extent, then a slow change—stopping before reaching the previous resistance. It was also noted that the longer the weights were allowed to remain on the plate the less the resistance became, there being a sudden decrease on application of the (small) weight, but a gradual decrease afterwards, the change being more noticeable the first few minutes. These results agreed with those of Professor Mendenhall in this respect, and it is curious to note that the curve for changes in resistance due to change of contact resembles very closely that found by Professor Mendenhall in his study of the influence of time on the change in the resistance of a carbon disc of Edison's Tasimeter (see *Am. Jour. of Science*, vol. xxiv.).

THE SOLUTION OF MUNICIPAL RAPID TRANSIT.[1]

BY FRANK J. SPRAGUE.

THE presentation of this subject before the American Institute of Electrical Engineers for discussion seems to me most opportune. It is a question of great importance, and one for which a definite solution is fast becoming imperative. To those of us who believe that the solution is to be found in the application of electricity, it has a special significance, and I trust that what I say may bear fruit by starting a general discussion of the subject, not only among electrical men but the general public as well.

More attention is now being paid to the question of tramway traffic than ever before. The reason is not only the comparatively high cost of operation under the present almost universal system of horses, but also because the public are beginning to feel and the street railway men are beginning to see that it is a system behind the times. Laying all humanitarian questions aside the public demand a better and a more rapid service. Railway men want to give it, provided they can do so for the same or less money than they are now spending.

To quote from a New York evening paper:

"The rapid transit question has steadily pressed its way to the front of subjects demanding immediate attention, until it now stands in this city the foremost question of the hour.

"The fact is made evident by the eager discussion upon every hand of the very best means by which the end may be attained with the least possible delay. The total passenger traffic, that is, the total number of persons carried, of this city, has increased at the rate of over 140 per cent. in each period of ten years since 1866, and is now something over 325,000,000. At the same rate of increase it would amount in 1890 to over 500,000,000, and in 1900 to 1,225,000,000."

There is every reason to believe that the through traffic will increase as much as expected, because the city is growing rapidly and its business section is continually enlarging and pushing northward, forcing the larger part of the population, especially the laboring classes, to seek homes in the upper portion of Manhattan Island and the annexed district, where rents, already increasing because of the increased facility of access, are still lower than can be readily commanded for business purposes in the lower part of the city. The elevated roads of this city, although carrying 500,000 people a day, do not answer the requirements of rapid transit, either local or through; nor is it possible for any two-track railway to do so.

By rapid transit we do not mean merely through transit; we ought not to consider alone the methods of transportation from one end of the city to the other, or from the city to the suburbs; we are likewise called upon to find some means by which the local traffic shall be benefited. Everything which lessens cost of operation, increases speed, reduces intervals between cars, increases the number of cars and makes extensions possible, aids rapid transit, no matter whether surface, underground or overhead.

With the same cost of operation, provided the motive power is materially cheapened, a greater number of cars can be run, intervals can be shortened up, large cars can be run in the place of small ones, better attention can be afforded, cars can be better heated, lighted and cleaned; they can make better time, people can be carried further for the same money, branches can be opened in districts which would otherwise not pay, and what is all important, more passengers can be carried, and for this reason alone more money can be made. For years an attempt has been made to replace the horse with motors of various descriptions—compressed air engines, fireless engines, hot water and soda motors, naphtha and petroleum engines and steam engines. But we can safely say that the question has to-day narrowed itself down as between the cable and the various electric systems for surface work, and between electricity and steam for elevated or underground work.

In order that we may be in a better position to judge of the comparative economy and the relative advantage of present and proposed methods of traction, I will briefly consider, first, the use of horses.

Two distinct methods are recognized among street car men in the handling of their stable equipments. In one, the stock of horses is kept as low as possible; they are worked hard, making 14 or 15 miles a day, and the depreciation is very heavy. In the other the stable equipment is increased; the horses are kept in excellent condition; their average daily duty is reduced to 10 or 12 miles, and the depreciation is lessened.

Assuming the cost of a horse as $150, and the cost of feeding and caring for him as $180 per annum, it would seem that any accurate knowledge of the average life of horses under different day's duty would soon determine the proper amount of the latter.

All railway returns do not, strange as it may seem, give accurate information on which such estimates of cost can be made; but from such facts as are given we may deduce the following: Taking the returns for 1887 for the five largest roads in Massachusetts, we find that they show 6,909 horses and 1,410 cars; that the mileage made was 12,884,665, and the passengers carried, 76,187,842.

Dividing the average daily mileage by the number of horses, and multiplying the number of horses in a team, we find only 10.26 miles as the average daily duty for all teams, sick or well. Horses which are on duty make from 12 to 14 miles.

On the West end road of Boston, which is now the largest street railway combination in the world, having about 212 miles of track and over 8,000 horses, 10 per cent. of the horses are counted as being off duty from illness, sprains, shoeing or other causes; and the balance of the horses average about 12 miles a day. A car day is estimated at 10 to 11 hours, and from 45 to 50 miles, and eight horses are allowed as the active force.

The rule given me by one of the officials of this company as a fair one to determine a stable equipment is, to divide the total daily mileage by the miles made in a car day and multiply it by nine, adding what is necessary for hill horses. Hence, if 50 miles is a car day duty, a daily run of 1,600 miles would require a stable equipment of 288 horses besides those for hill work.

On the Fourth avenue line in New York, the stable equipment is determined as follows: A car day is 11 hours, and eight horses make about five trips, aggregating about 50 miles. To this number is added 10 per cent. for illness, sprains, etc., and 10 per cent. for emergencies. On this road is illustrated the influence of an important factor in horse car work—that is, the position of the stables. Horses from the upper stable are limited to 11 miles, or otherwise they would have to make 22 miles, while horses from the lower stable have to make about 13½ miles, or considerably more.

The average cost of motive power per car day throughout the United States, that is, for from 10 to 11 hours and trips aggregating from 45 to 50 miles, is about $4. This counts only those horses on actual duty on the road. The cost of motive power per car day for equal mileage in Richmond is less than $2 on the heaviest sort of grade work. The total operating expenses of a horse railway average for the five largest roads in Massachusetts, 25.15 cents, and for all the roads in Massachusetts 24.7 cents per car mile; and the ratio of operating expenses to gross receipts is, for all the roads, 86 per cent.

The cost per day per horse, based upon the returns of four of the largest roads in New York, is 54 cents, and the cost per car mile from 9½ to 10½ cents per car mile.

In addition to the regular depreciation there is ever present, danger of an epidemic in hot weather.

Since the cost of the motive power alone—that is, the cost of harness and stable equipments, horse-shoeing, renewals, provender, hostlers, etc.—is 40 per cent. of the total operating expenses, it will at once be seen how vitally important any material saving in the cost of motive power becomes. If, as we claim, the cost of motive power in an electrical system is one-half or less than that in a horse system, the percentage of gross receipts available for interest and dividends is more than doubled.

Furthermore, when we remember that the average running time for horses is only five to six miles per hour, we have another reason which constitutes an unwarrantable objection to the uses of horses for rapid transit.

Among the systems which has been proposed to take the place of horses and which has given the most promise, and met with the greatest success where heavy grades and traffic exist, is the cable system. With its general features you are probably familiar.

There are, however, a great many objections. One of the most serious is the great initial cost of the construction and plant, the cost of the conduit alone ranging anywhere from $50,000 to $80,000 per mile of single track, making the investment so large that none but roads having heavy traffic can permit of the expense.

The conduit is necessarily large and costly in order to accommodate sheaves of sufficient size to prevent too great a loss in friction, and on account of the position of the cable and pulleys it is difficult to clean it. This large size also makes it difficult to construct a conduit which will not, because of the traffic and weather strains, be distorted and have the slots forced together or apart. The depth varies from two to three feet, more often the latter, and in any city street this is almost certain to interfere with steam, gas, or water pipes.

Each section of the line being a unit and operated from one cable, a break in the cable will suspend the entire traffic of that section.

A broken strand is apt to foul the grip and pile one car on top of another, as happened in Philadelphia, or suddenly start a car which is at rest, as recently happened on the 125th street line in this city. The cable is a heavy, cumbersome affair, 1¼ inches diameter, and weighs about 13,000 pounds to the mile.

It is found that it is best to make these cables in 20,000 ft. lengths.

If a cable is stranded it cannot be used until repaired; if it is stretched 1 per cent. it is considered unsafe. These weaknesses of the cable system render it necessary to have a duplicate cable ready for instant use, and a double line of sheaves.

1. Read before the American Institute of Electrical Engineers, June 19, 1888.

With a full load, not over about 20 to 25 per cent. of the power of the engines is actually used for the propulsion of the cars, the balance being for moving the cable. With any light load the efficiency is even less. But it has been found advisable to have even greater power than this, most of the companies having from two to four times as much engine power as is required at any time and, from one and a half to twice the boiler power. This is necessary, because if any part of the cable engine breaks the whole section of the system is disabled.

Every turn in a cable brings a strain upon the grips and reduces the life of the cable, and any increase in the speed at which a cable is driven likewise shortens its life.

Difficulty exists in turning corners, expensive drums, and oftentimes auxiliary cables being required. Constant care and attendance is necessary in lubricating the carrying and curve pulleys, and in taking care of the slots and switches, the estimates for Boston being about $3.20 per day per mile of single track, requiring the time of one man per mile. It is impossible to work turnouts, cross-overs or sidings without auxiliary cables, or to operate single tracks.

A line once being put in, any extension is expensive and difficult because of the terminal machinery which is necessary and the definite length of the cable.

The speed is limited; a car cannot travel faster than the cable and thus recover lost time, except on down grades; nor can it travel more slowly save by permitting the cable to slip. The regular speed then, must be the same in the most crowded sections of the street as in the less populated sections.

The starting is often with a jerk, and the whole motion of a lurching, unequal, unpleasant character, exceedingly disagreeable when first experienced.

Success in the cable railway system considered by itself depends largely upon the condition that a line of reasonable length shall be so located as to warrant frequent car service.

The chief advantages of a cable are, the cheapness, as compared with horse-power, of operating a heavily patronized road at a comparatively fixed rate of speed with no regard whatever to grade or gravity; but this cheapness is not inherent to the cable system, but due rather to the fact that steam has such a tremendous advantage over horses.

The motive power operating expenses vary from 50 to 70 of the cost of operating by horses.

Now, what is it electricity by some of its systems promises us for the ordinary street traffic? What are its advantages? First, it will do the work, and in a far more satisfactory manner and at a greatly lessened cost of operation than with horses. Electricity is simply an agent for which we have to pay a certain proportion to carry the power of our steam engines to take the place of the horse. Since not only on levels but also on the up and down grades an electric car can be run much faster than a horse car, and because it can be gotten under way and stopped much more quickly, the mileage with any given number of cars can be increased, the mean running speed increased and, the same time intervals made with a less numbers of cars; or on the other hand, shorter intervals be made with a given number of cars. The equipment will occupy about 35 per cent. less space, the horse space being saved, and this fact, together with the ability to back when necessary, and to quickly gain headway, enables an electric car in narrow and crowded streets to work a passage through where horse cars would be at a dead stand still. Not only can cars run down grade faster, but also with much more safety, because of the possibility of the instant reversal of the motors in the event of the parting of the brake chain, and when arriving at the top of a grade, the faster the motor runs the better. It has not got to be held in to save it.

The riding of an electrical car is far easier than that of any cable or horse car, starting and stopping more easily, and being in a large measure free from lurching and oscillation. The cars are much cleaner. They can be brilliantly lighted, and they can be heated by electricity. There is no dust such as rises from the heels of horses. The sanitary conditions are entirely altered, and the health and comfort of the whole population is conserved. Stables with all their unsavory characteristics and the consequent depreciation of the value of adjacent real estate disappear. No sand is needed on the pavements, and the pavements are not so quickly worn out; often no centre paving is necessary. It becomes feasible to operate branch lines, and also combinations of grades, curves, and ill-conditioned streets which would be prohibitory to any other system. It is not to be claimed that any one system of electric traction has all these advantages; but in some form or other they will be found.

It has been said that an extended system cannot be operated by electricity, that the lines may break down, that a large number of cars cannot be operated simultaneously, especially when bunched up, that wires burn out, that brushes burn up.

True, these things have happened, and in case of defective workmanship or carelessness they may happen again. Although electricity is a force of unknown nature, and we know it by its effects, it is a folly to hold that whatever faults in machinery may exist or accidents occur do not come within a very narrow and limited category; and powerful and mysterious as it is, and answering an impulse with the rapidity of lightning, it is at the same time the most tractable and law abiding agent with which we have to deal.

There is not a freak of which it is capable which we can not guard against. It has not an attribute of which we cannot make positive use. It has no power of damage which cannot be controlled.

The development of its application, the mistakes which have been made and the accidents which have occured are but the mile-stones and guide-posts of the highway to success.

Were it not for the occasional failures there could be no advance.

As a matter of fact there is no apparatus for the transmission of energy that compares in simplicity and efficiency with the dynamo-electric machine and the electric motor. There is no machine in existence which, when thoroughly and well built and decently cared for, is less liable to get out of order, and will stand harder usage and greater variations of work with a minimum of attendance and care. A motor has but one moving part, and that has a rotary motion. Its torsional effort under given conditions is a constant, and when properly built and proportioned some types have over a wide range the remarkable and unique quality of having this torsional effort vary as the square of the current used, a feature of marked importance in traction work.

As modern as the motor is, the peculiarities of all its phases are just as well known and capable of just as graphic representation and forecast, as are those of the steam engine. This can best be shown by reference to some curves which illustrate the characteristics of some of the Richmond motors, and have the same significance that an indicator diagram has for an engine.

For convenience these curves are plotted on both sides of the axis (Fig. 1). The ampere turns on one leg of the field magnet are plotted as abscissæ. The curve *O A* gives the characteristic of the machine when run as a series dynamo on a variable external resistance at 856 revolutions. *B C* represents the equation of counter-electromotive force with an initial electromotive force of 400 volts. I have allowed an increase in the actual resistance of the machine of 10 per cent. for heating and other causes. The speed of the armature, the miles per hour made by a car with the Richmond gearing, the tractive effort in pounds for one motor, and the horse-power units are, for convenience, all laid off as negative ordinates. Equal units of horse-power and torque are laid off as abscissæ, so as to make the maximum points coincident.

The first important curve which we have to get is the speed of the motor in terms of its current. We have the law that the speed is directly proportional to the counter-electromotive force developed, and inversely proportional to the strength of the field. In other words, the speed curve, *E D C*, in terms of the current, is plotted from the curves *O A* and *B C*, and the speed for any current is found by multiplying 856 revolutions by the ratio of the ordinates corresponding to that current.

The next curve with which we have to deal is that of the work of the motor in terms of the current; that is, the curve *O F C*, which intersects the axis of *X* and at the same point as the curves of speed in terms of the current and the counter-electromotive force.

A third and most important curve is that of the work of the motor in terms of its speed, which is the curve *O D G* plotted from the curves *E D C* and *O F C*, with the horse-power units transferred to the axis of *X* as abscissæ. For instance, following the negative ordinate for 30 amperes, we find, at the proper intersection, a speed of 630 revolutions of the armature, or 4.82 miles per hour of the car; and, at the insection of the work curve, that 11.65 h. p. is developed. These two values give us the point *S* as one of the points of the work curve, and so on.

Referring to the work required to be expended on a car, we have from the formula—

$$\text{h. p.} = \frac{w\,n}{335}\left(\frac{k}{2000} \pm \sin\,\theta\right)$$

where w = wt. in lbs.,
n = miles per hour,
k = resistance to traction in lbs. per ton on level.
θ = angle of grade,

the work which is required for any grade, speed and weight. Hence for any given conditions we can plot the equation h. p. = $a\,n$, and by its intersection with the curve *O D G*, find at what speed the car will be moved by the motors and what current is required, if we know the gearing. On the other hand, if we assume that a certain load on a certain grade shall be handled, and we elect that it shall be done with a certain efficiency of the motor, or on a certain part of the work curve, we can draw the car curve for this intersection and then deduce the speed of the car and, from it, what must be the ratio of gearing to enable the car to be handled by the motors under these conditions. Four of such car curves are drawn—*O R*, which shows the maximum which could be moved; *O M*, which shows what can be done at 50 per cent.

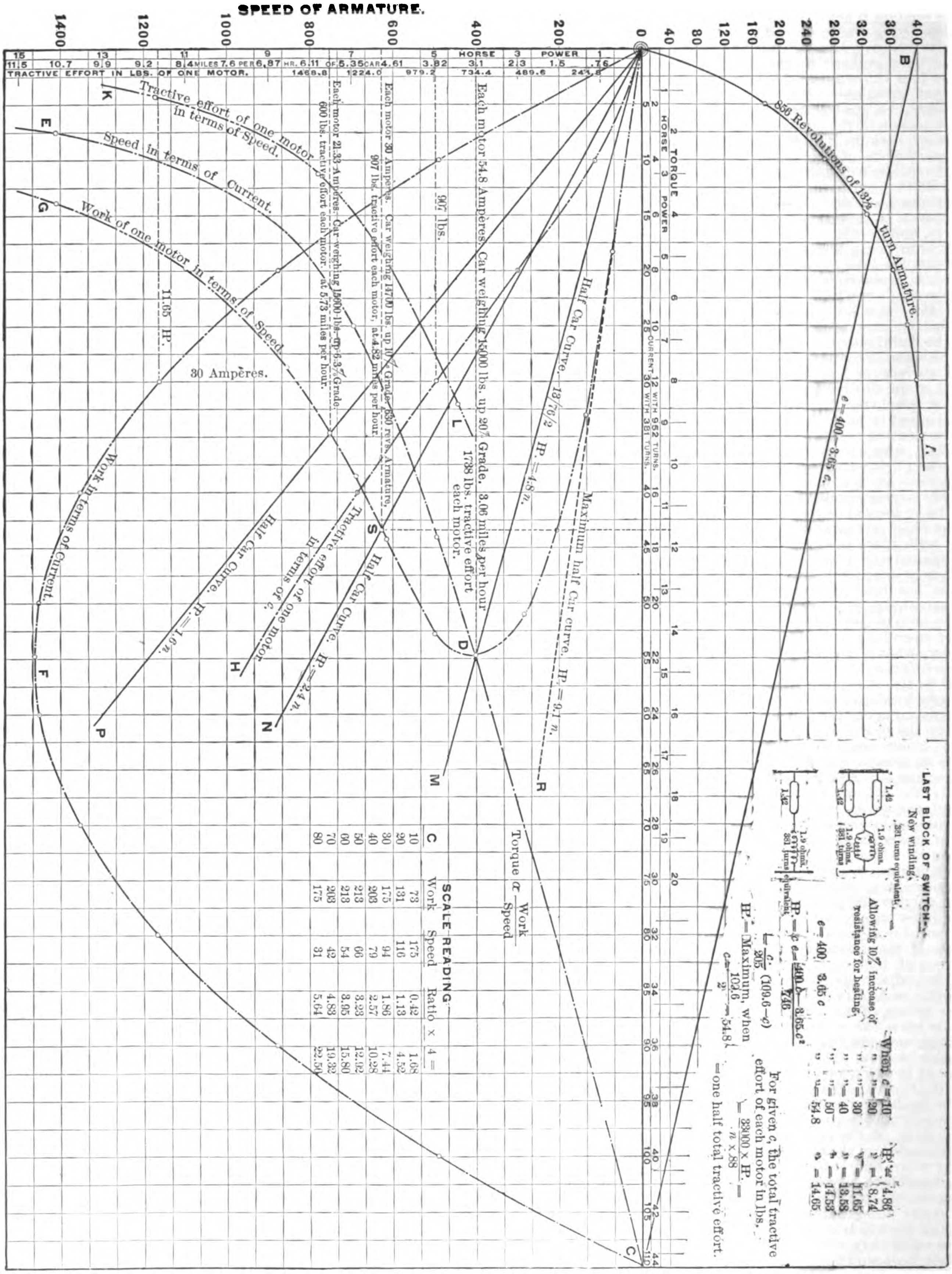


FIG. 1.—Curves Illustrating Electric Railway Motor Characteristics.

efficiency; *O N* and *O P*, showing the equations which are constantly in practice.

In the actual computation 10 per cent. extra is allowed for losses from friction and so forth.

With the Richmond gearing, and a car equation of h. p. = 4.8 *n*, we would have a car weighing 14,700 pounds sent up a 10 per cent. grade at 4.82 miles per hour, and each motor would take 30 amperes of current. If the grade or weight were increased, the curve *O N* would be carried toward *O M*; or, if the ratio of gearing is changed, then, with the curve *O N* in its fixed position, the weight of car or grade could be increased, although the speed of the car would be reduced. Other curves are shown, *L K* showing

the tractive effort of the motor in terms of its speed, and OH showing the tractive effort in terms of the current; the tractive effort varying, of course, as the work divided by the speed.

The variety of problems which can be worked out from this curve sheet is very large, and they become of vital importance in dealing with any new work. Nothing could show more clearly the value of a mass of iron in the field magnets (as I have always held to be the proper method of building motors), and the exceptionable qualifications of motors for tractive purposes. Any change in the switch or any change in the potential will vary these curves materially. One fact, however, is to be noted; no matter how the field may be changed, the speed of the motor at 50 per cent. efficiency is a constant.

The connection of the motor to the driving wheels has been attempted in a great variety of ways, and nearly every mechanical device possible has been used. Often the motors are carried upon the car body and connection made with the wheels, which should bear a variable position relative to the car, by means of friction wheels, sprocket-wheels and chains, or by belts, ropes or wire chains with tightening devices. The motor armature has been mounted directly on the axle, and also hung on a frame between the axles, being connected to both wheels by cranks and side rods, necessitating equal speeds of revolution of the motor armature and the wheels.

These methods are all crude and unsatisfactory. They are makeshifts, and ignore the most important and essential facts which have been developed in car and motor construction. There is to my mind only one good way to connect a motor, and this is to centre the motor upon the axle, supporting it flexibly from the car body or the car truck, and driving by gearing with one or two reductions according to the service which is demanded. This is the only way in which an absolutely safe and positive connection can be depended upon both for ordinary work and for the normal and sudden strains called for in an emergency.

Properly made, the friction of this method of reduction is very low, the motion is smooth and free, and reasonably noiseless.

The proposition to couple the motor so that it shall make the same number of revolutions as the axle, ignores one of the most important points which makes light weight in motors possible, and that is the high speed at which the armature can be run.

I have pointed out, in describing the curve characteristics of a motor, one of the essentials to determine the proper ratio of reduction for any motor when required to do a given work. I may here add a brief formula, which will also serve as an index in this matter: Let f equal the maximum velocity in feet per minute at which an armature at any time is allowed to travel; n the number of miles per hour to be made by the car; D the diameter of the car wheel in inches; d the diameter of the armature in inches. Then the ratio of the gearing must be expressed by the equation,

$$R = \frac{f D}{88\, n\, d}$$

For instance let $f = 4{,}000$, $n = 12$, $D = 30$ and $d = 10$; about the values which exist in street car work. Then

$$R = \frac{4{,}000 \times 30}{88 \times 12 \times 10} = \frac{125}{11},$$

and this should be made in two reductions. As in our largest trucks, let $f = 4{,}000$, $n = 35$, $D = 42$ and $d = 18$. Then

$$R = \frac{4{,}000 \times 42}{8 \times 35 \times 18} = \frac{100}{33}.$$

In the application of electricity we are limited to no one system; we have a choice which will permit us to meet any exigencies or conditions of traffic. There are two kinds of application.

In one each car is perfectly independent of the other, receiving its charge at the central station and acting as an individual unit. The storage battery method is such a system.

The other is a system of direct supply, and, unlike the battery system, where the energy of the steam is four times converted, it suffers only two losses. In this system the current is delivered directly to the line, from which the motors as they move along derive their current. There are several forms of conductors, centre and side rails, the main tracks, conductors carried in conduits, and overhead. Either a complete metallic circuit may be used, or one conductor with the rail and earth return. The machines can be operated under three different systems—the series, multiple series, and parallel circuit distribution.

Of these various plans, I shall discuss only three—the storage battery, the conduit, and the single overhead wire system with underneath contact carried on the car, and for the systems of distribution the parallel circuit system only.

The storage battery from the time of its first introduction to the public has offered a tempting solution to the application of electricity for surface transit. The great advantage of the battery system is that while most of the advantages of an electric system are retained, such as perfect control of the car, ease of manipulation, cleanliness and so forth, each car in itself becomes an independent unit not dependent upon any general accident to a system. As attractive a solution as the storage battery at first sight seems, there are many points of disadvantage in the present state of its development. One of the most important is the excessive weight of battery which is necessary under the conditions of service which are met with in this country, from 3,400 to 4,000 pounds being the ordinary weight. Not over 10 per cent. of the lead in these batteries is actually used for storage. On account of the weight and the room which the battery takes up, there has to be a radical change in the construction of the cars, and while old cars can be made use of by a great deal of patching, it is not advisable to attempt this. This change makes the present cars useless, and likewise increases the cost of new car bodies.

Then again, while the tracks as they exist may stand the additional weight of motors on a four-wheel car, the additional weight of battery, making the total weight on a given wheel-base double what it was before, will render it necessary on a great many tracks to relay the road-bed, or to put in 8-wheel cars. Of course these objections are not so serious on a new road as they are on an old one.

But I confidently expect to see, in the not so very distant future, the weight of battery necessary to handle a car reduced one-half; this, besides overcoming some of the objections which exist now, will halve the expense of handling them at the central station, and will also allow the present standard width of aisle to be maintained.

The present excessive cost and unknown depreciation of the battery, its lack of efficiency, limited capacity, the fact that only a portion of the charge can be taken out with safety, and the reduction of its output when sudden demands are made upon it, are all of such a character as to leave wide room for improvement. The loss of efficiency in conversion I do not esteem of such vast importance, because, in any large system where the engines are kept going under a steady load, the cost of operation will not be so very much more than where operating under continually varying loads. The limited rate of discharge, as well as the limited capacity, limits the grade work to which a battery car can be subjected. For instance, as batteries and cars are now made, we can easily have the following combinations of weight:

	Pounds.
Weight of car...	5,000
Batteries...	3,600
Motors and other apparatus ...	2,000
Sixty-five passengers...	9,100
Total...	19,700

To start and to accelerate this load on, say a six per cent. grade, demands a discharge rate which no storage battery company cares to recommend.

As near as it is possible for us to get at a correct estimate, on a new road of moderate grades a storage battery system could be operated at about 80 per cent. of the cost of operation by horses. This is about double the cost of the direct system of supply on a large scale.

But the storage battery is not going to stand still.

Many men with abundant capital are striving for improvement, and I think there is but little question that batteries will be reduced in weight, increased in capacity, and made far more efficient and long-lived.

The conduit and overhead systems have one point in common. Both are dependent upon a central station, and the actual cost of operation (except for the care and maintenance of the conduit itself) would be about the same. There is, however, a great difference of investment. Both must have about the same amount of copper, and, to be effective, about the same distribution.

The difference of cost then is practically the difference between pole erection and conduit laying, and this will be from $25,000 to $30,000 per mile. As an investment, of course it means that with the conduit very much more money has to be earned. The electrical conduit can be built for less money than a cable conduit, because it can be made of less depth, but it cannot be built without due regard to the strains of street traffic and weather, and with proper drainage and cleaning facilities. The advantages of the conduit are chiefly that there are no overhead obstructions. Its disadvantages are, besides its great cost, the lack of cleanliness, increased possibilities of leakage, and greater difficulty of repair in case of accident. Recognizing, however, the demand which exists in certain places for a conduit, we have developed such a system which has many of the same elements of simplicity and reliability that our overhead system possesses.

The working conductor carried in the conduit is divided into sections, which at intervals of every block or half block, as desired, are connected through automatic cut-outs in man-holes to the main conductor, which is continuous and enclosed in a lead or iron covered cable. Any accident to a section, such as flooding, short circuiting, and so forth, will simply cut out that particular block.

For the immediate solution of the question of more rapid and cheaper transit, in many places the overhead system is most available.

I am aware that a great hue and cry has been raised, especially

of late, against any electric wires whatsoever being used above ground. The feeling which exists is not entirely unreasonable; in fact it is easily accounted for by the most casual inspection of the condition of the wires of this city. But many of the objections which are raised against all overhead systems are not necessarily inherent; they are very largely due to gross carelessness in construction, engendered by a faulty municipal administration. We have in our cities little or no active control or oversight of the wires which have been put up in our streets. Year after year, from the earliest telegraph days, those in control have granted to telegraph, electric light, telephone and electric power companies innumerable more or less limited franchises for stringing or hanging wires through our streets. These permits have often been granted without any restriction whatever; they are often granted for a "consideration." The erection and maintenance of these lines being a large factor in the cost of construction and operation of the companies, they have been put up with little or no regard to public convenience or safety—certainly with no regard to any æsthetic tastes—and oftentimes with an utter ignorance of the proper methods of construction. Fire underwriters, in their wisdom, have demanded an insulation to stand fire, forgetting, or in apparent ignorance of, the fact that protection from moisture and leakage is of far more vital importance. Hence we have that treacherous wire known as "underwriters' wire," or more commonly among electricians, "undertakers' wire."

The poles have, until lately, been of the cheapest construction, badly set and continually marred and weakened by the spurs of the linemen. New lines have been continually added, and poles intended originally for a certain number of wires are now carrying double or treble that number.

The electric light companies, after cutting out a lamp for which a contract has expired, leave the bights of their wires hanging in loops. The telegraph and telephone companies allow thousands of miles of "dead" wires to remain overhead, or to hang in festoons from every pole, which in some sections are utilized as clothes lines or are used by the street urchins as kite traps.

They cross and recross the streets at every angle, every elevation, and at every tension. They are strung surreptitiously on poles to which no right exists, and over buildings for which no permit has been granted.

No one seem to have the power to compel a change or improvement in these practices, and the companies themselves never will do it until so compelled. The sharp competition in the lighting business, the small profits derived therefrom, the great trouble of hauling down and getting rid of miles of dead telephone and telegraph wires, all these interfere with a satisfactory straightening out of the existing system of overhead wires.

In all improvements for public improvement we have to consider the arguments for as well as against such improvements. It is not sufficient that we say that there are disadvantages attending the introduction of the system, we must consider likewise the possible advantages; and this is especially important when we consider the use of the overhead line in a system for propelling street cars. Such a line being part of an investment of a company which has practically no competition on its own street, and whose own interest would require it to keep its line in first-class condition, can be put up in a manner presenting few of the objections which are generally urged against a system of overhead wires. I would not urge its adoption for all places, but in all suburban districts, for comparatively narrow streets, for all streets operating under an elevated railway structure, or where the tracks are near a sidewalk, the direct system of supply from an overhead line with underneath contact, presents advantages which, once appreciated, far outweigh the possible objections of such a system.

Several methods exist in which the wires can be erected. One in which span wires, at a distance of 125 feet apart, reach across the street from building to building, or from pole to pole, and have suspended from them, directly over the track, at a height of about 19 feet, a longitudinal wire of not more than a quarter of an inch diameter, this wire being termed the "working conductor." This should be of the very strongest character. It should have a high elastic limit, great tenacity, and resist corrosion and oxidation.

Its conductivity is a matter of less importance, since not upon it, but upon the main conductor which supplies it do we depend for the main transmission of our current. Hence the elements of strength and reliability are of far more importance than conductivity. We have found that the best wire for this purpose, is that alloy known as "silicon bronze"—a wire which can be drawn for a tensile strength of from 75,000 to 150,000 pounds per square inch; that is a strength higher than that of the best commercial steel. Such a wire it is almost impossible under conditions of service to break, and its life is very long. Samples of hard drawn copper wire, which possesses only from one-third to one-fifth the tensile strength of this wire, show, after months of the severest usage, scarcely any signs whatsoever of abrasion, or reduction in size. This wire is of the same size whatever the distance run or the number of cars operated; and the main conductor may be stretched along the buildings, through a side-alley, along poles, underneath the elevated structure, or buried underground.

In the latter case there would be in a single track street only one longitudinal wire, and that one over the track, and it would be no larger than a single telegraph wire; and in the case of a double track, there would be only two wires stretched longitudinally along the street, and these would be as taut as harp strings.

Switches and cut-outs are put in main and working conductors in such a way that the different sections can be operated independently, and cut out automatically or at will.

The span wires can be as much above 19 feet from the ground as is desired. Of course, where a telephone or electric light line crosses the street and may break and fall upon such a conductor, it would be necessary to have one or two guard wires above it.

These guard wires can be very properly carried from the span wires themselves. Furthermore, if desired, the stretches between the span wires where the guard wires are used can be very much longer than 125 feet; they can be even as long as 500 or 600 feet—that is, two or three city blocks—in which case the two guard wires form a light suspending structure, from which, at intervals of a hundred feet, the middle wire is carried in a straight line.

In very many cases it is unnecessary to have any span wires whatsoever. In those streets where the track runs near the curb a light pole with an ornamental bracket is all that is necessary.

In a broad street where the tracks occupy only a small portion of the street, and are near together, a line of poles of ornate design with light arms projecting on either side can follow the centre of the street. Oftentimes there is a middle division or park, such as exists on the Boulevard in this city, which will afford space for the poles without interfering with anything.

These same poles can be used for lighting the street.

On streets occupied by elevated railroad structures, the structure itself can be used as a support for the overhead wires.

Among the numerous places in New York where an overhead system could be put in perfect operation are Eighth avenue, from Fifty-ninth street up; the Boulevard, from Fifty-ninth street up; a part of the First and Second avenue lines; the Third, Sixth and Ninth avenue lines, and all the suburban extensions in the annexed district.

To avoid any extra strain on this wire, the current is taken off by a flexibly supported trolley, carried on the car, and making contact underneath by upward pressure as will be more specifically described later.

With such a system put up in the proper manner, it is almost impossible for any accident to occur which will disable the line or prove a hindrance or annoyance to the public in any way.

The wires are perfectly clear of the operations of the firemen, and should they in any place interfere the obstructing section can easily be cut out without disabling the remainder of the system.

The question of "electromotive force," or electrical pressure, so to speak, to be used, is one of great importance. I do not favor going above 400 volts, and this on a continuous current circuit. This is less than one-seventh the electromotive force which exists on many of the arc-light circuits in this city; and the current being of a perfectly smooth and continuous character is free from the danger which might be feared from a current of equal electromotive force of the alternating or pulsating character.

In point of fact, in Richmond, a very large number of our men have received the full E. M. F., from our line without any injury.

On a dry day the trolley wire has lain coiled up on the ground while the cars are in operation; and while certain changes were being made in the overhead circuit, the men work continually with the current on the line. I have never known a constant potential current of 400 volts to cause of itself the death of or serious injury to a human being.

The past year to me has been one of great responsibility and wide experience. It has been a hard year. But the experience and expense are as nothing compared with the great value of having been, with my associates, instrumental in bringing to a successful issue one of the most important pieces of electrical engineering with which I have ever had anything to do. Among the roads which we have equipped the most important is, of course, the Richmond Union Passenger Railway, which now has six times as many machines in operation as any other road of its character in existence, at which every difficulty to be encountered in an overhead system on heavy grades and with sharp curves has been made, and which has for all time conclusively settled the question of the economical operation of a large road by the method of direct supply.

I will briefly refer to the road, giving some illustrations of its principal features, and some facts about its operation.

Some idea of the character of the road may be gathered from the following: The total trackage is about twelve miles. It runs a very irregular course and reaches the principal parts of the city (Fig. 2). About nine miles of street are covered. The central section is a double track for a distance of something over two miles, a part being laid on paved streets, and the balance on macadam or unpaved streets; all the extension and branch lines are on unpaved streets, many of them in clay soil, which in wet

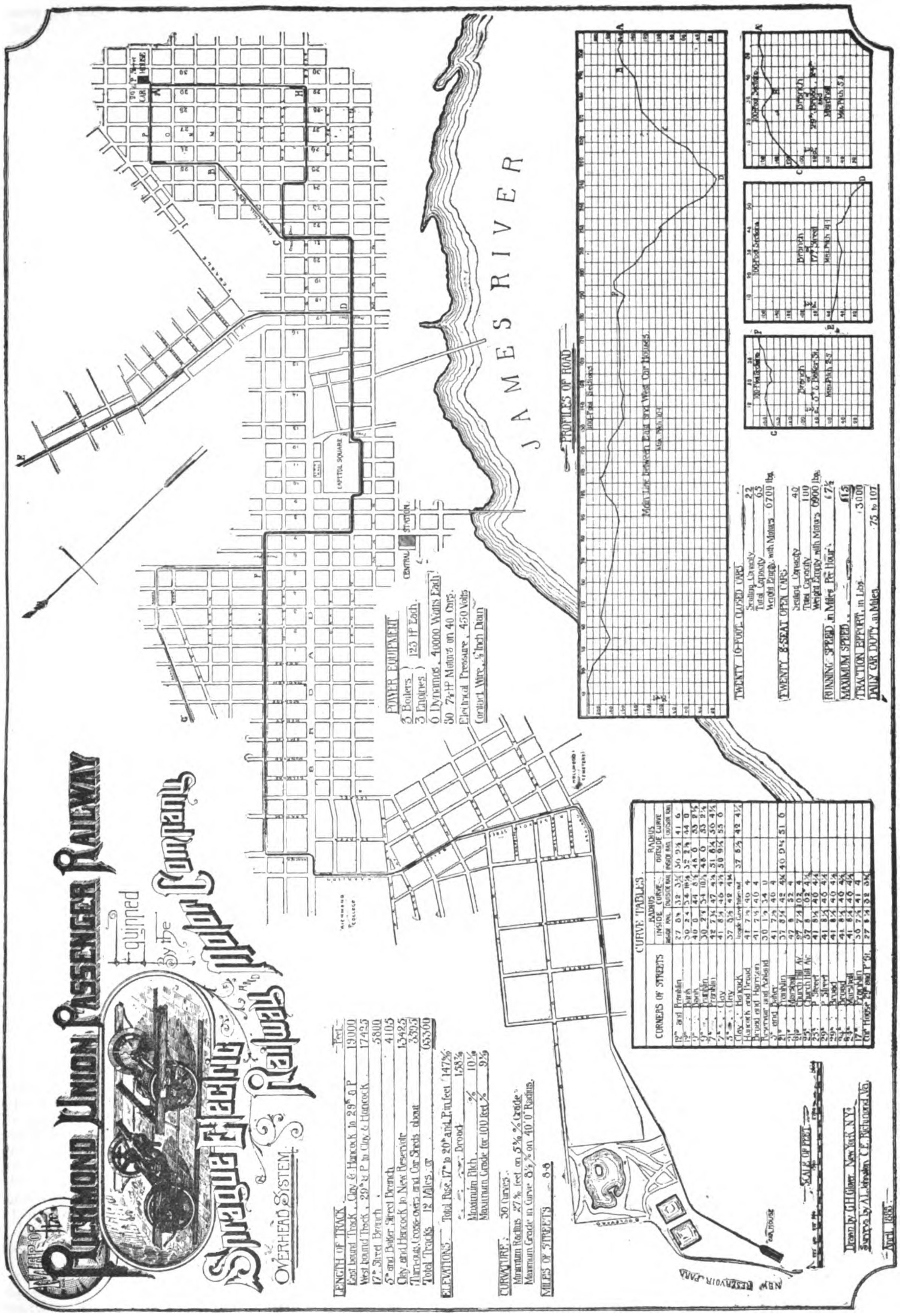


FIG. 2.—Map and Data, Union Passenger Railway, Richmond, Va.

weather covers the tracks, and where it would be an impossibility to operate horses without paving. The double track section partly encircles the old State Capitol and presents difficulties rarely equaled elsewhere. This part of the line in a distance of less than one thousand feet has on both east and west bound tracks, four curves, the inner rails of the west bound track being of about 27, 30, 40 and 50 foot radius. The power necessary to run these sharp curves is much increased by the fact that grades are encountered on the curves as high as eight per cent., and the lay of the street has required some of the outer rails to be some inches below the inner one. Running eastward from the Capitol the road descends to a low valley through a series of grades varying from three to ten

per cent., and then ascends a series of sharp grades and curves in a new district to one of the car houses.

Going west from the State House the road rises to nearly the highest point in the city, and then runs through a residential district across the Richmond, Fredericksburg & Potomac Railroad, and after several sharp curves extends back a further distance of two miles to a second car house beyond the new reservoir. Two branches connect with its main line, one leaving at the old Market Place crossing, and paralleling the Chesapeake & Ohio Railroad, and terminating at its machine shops. The other runs into what is popularly known as "Africa," a section almost exclusively inhabited by colored people.

The narrow streets, their hilly character, and the lack of paving, especially in the new districts, has made the road one of exceptional difficulty to operate. There are no less than twenty-nine curves requiring bent rails, the majority being of sharp radius, five being less than thirty feet. There are also several sweeps or curves of large radius, several turnouts and cross-overs. The grades are the maximum ever ascended in practice by a self-propelled car depending on track adhesion alone, and many of these grades are very long. Going east there is one section of almost continual ascent for about 5,600 feet, with grades varying from three to seven per cent., and going west there is a stretch of 1,900 feet, with grades varying from three to ten per cent.

When we first undertook to equip this road in the face of these difficulties, there was the additional discouragement of the ridicule of a great many prominent street railway men and car constructors as well as electricians. It was only a comparatively short time ago that one of the leading lights in street railway circles made a report to the street railway convention in which he stated that unless some new invention should be made it would be impossible for any self-propelled vehicle to satisfactorily operate under the ordinary condition of street car service. He, as others, held that the grades and curves met in practice were so severe and the condition of the track so bad that a car propelled by its own wheels could not under any possibility, day in and day out, be relied upon to move itself. One electrician even made the statement only a short time ago that any man who should attempt to operate on more than a six per cent. grade would lose his reputation.

Reliability, economy, simplicity of construction and operation on a scale never before attempted, and under conditions which we could not foresee. This was the problem, and perhaps it was well we did not know the difficulties. Then again, while there have been strong friends of the enterprise in Richmond itself, there was a class that felt anything but pleasure at a stranger's advent.

The change of feeling with which this enterprise has been regarded by this doubting element is somewhat significant. When the franchise was originally secured the city was blest by one car-line only, and this had dingy bob-tail cars drawn by mules, which, on the heavy grades characterizing the topography of Richmond, made very slow time. The new districts were not reached at all. When the present line was proposed there were not wanting philosophers who knew that no road would be operated. Even when the tracks were down these same wise-acres predicted that no cars would ever move over them, and most certainly if they did, the time-honored mule would be called upon for duty. Even after the cars were put on the line experimentally there existed but little faith that success would be reached. But times have changed. The mules on the competing line are to give way to electricity. The citizens of Richmond are the strongest friends of the electric railroad of to-day, and as regards the street railway community elsewhere, the work which the road has done and is doing and the acceptance of the contract, speak for themselves.

The difficulties we have met are many. One of the most annoying at first experienced was that the cars frequently jumped the tracks. A large portion of the track was, as has been stated, laid in macadam and dirt streets, the latter being chiefly in new districts and in a soil of which the chief component was red or yellow clay, and although the curves were of sharp radius, only one guard rail was used, and they were not bound in by paving. The winter months brought frequent and heavy rains. The tracks were found to be settling out of sight in mud, and especially at the curves they were spreading. The cars being large and heavy, with a 4 foot 8½ inch gauge and a 6 foot wheel base, helped to make the curves spread by the tangential pressure of the forward wheels on the outer rails. Mud and stones would get into the grooves, and the cars, having a tendency to go ahead instead of being pulled around by the head as with horses, would climb the track, and before an inexperienced man could check them the wheels were down five inches in the mud alongside the stringer pieces and the track brakes hard and fast against the tracks. Sometimes it was lifting, sometimes prying, and sometimes a heavy hard pull on the part of the motors to get them back again. Experience, however, is a great teacher, and among other things which has been taught is this: that money will be saved by a good track construction and the observance of a few practical points. All curves should be bound in and paved, and this has since been done in Richmond. They should likewise have two guard rails, because it is much easier to steer a car by its rear wheels by holding them in place, than by allowing them to crowd the inner rail and force the forward wheels to climb the outer one. In dry weather, with the large wheel base and sharp curves, it is found advisable to grease the grooved rails.

Another point which has to be carefully taken care of is the character of switch which is put in for sidings and cross-overs. If drop switches are used, they should be of such character as to allow the car to come down easily; tongue switches are now being put in on all the new work which is being done. It is a rare thing at present to have a car leave the track. I have seen a car in the winter propelled for a hundred feet off the track, and also leave and go back on its own account.

The power house is situated two blocks away from the nearest point of the line, and is almost equi distant from its extremities. As a distributing point, it is, therefore, both theoretically and practically, a central station In the construction no expense has been spared, and the performance of the station has justified it. The battery consists of three cylindrical return tubular boilers of the latest pattern, mounted on a Jarvis patent furnace, their capacity being 125 h. p. each. The water is taken from the city mains or from a well. All feed-water connections are of brass pipe. From the pumps the water passes first through the feed-water heater, where it is heated from 150 to 200 degrees F. From there it goes to the filter. The draft in the furnaces is regulated by an automatic steam damper regulator, which, with anything like regular firing, keeps a pressure within two pounds of that for which the regulator is set.

The boilers all feed into one main feed steam pipe, which in turn leads to a separator, a large iron cylinder into which the steam passes, the water falling to the bottom and the dry steam being carried off at the top. All live steam pipes in the boiler room are covered with magnesia.

The present battery occupies less than half the available space in the boiler room, so that four more boilers can easily be put up when it becomes necessary to enlarge the plant. Two more have just been added. An important feature of these boilers, which are the source of power of the whole system, should not be overlooked, that is, the quality of coal burned. Where a very perfect combustion is obtained a grade of coal can be used which would be impracticable in an ordinary furnace; the mixture at present being used is two parts screenings to one part bituminous, costing from $1.75 to $2 per ton delivered. As the station is only three hundred feet distant from the depots of three railroads, coal can be obtained almost at the door. From the boiler room, both the steam and exhaust pipes run in an underground, mineral-wool-packed trench to the engine room.

The railroad engines, of which there are at present three, are of the Armington and Sims high-speed type, and develop, when running at full load, 125 h. p. each at 250 revolutions.

Each engine drives two special Edison dynamos of 40,000 watts capacity each, wound for 500 volts maximum pressure. The dynamos feed into copper "bus" bars, supported on the walls by porcelain insulators.

Each machine has its independent ampere meter, and in addition there is a general ampere meter at the end of the positive "bus" bar. From this bar the current passes to four snap switches, each switch being connected through a three-plug safety switch block to one of the feeders supplying current to the main line wire. These four-feeder wires tap into the line wire at different points, thus maintaining the pressure approximately equal all along the line. At the ends of one of the feeders in the central station pressure indicators are to be attached which will indicate the voltage at the junction of one of these feeders with the main current wire, and this will serve as a guide.

The electric circuit consists of two parts—the overhead and the ground circuit, each being of compound character. Along the curbstones at distances of 125 feet are 30-foot poles, inserted into the ground a distance of five feet. Great difficulty was experienced at first on account of the clayey character of the soil, and it became necessary at the corners to put in very heavy poles, which were imbedded in concrete and stones to prevent settling out of place after heavy rains. These poles carry the main circuit which extends throughout the entire length of the roads, and is a copper wire three-sixteenths of an inch in diameter; this is called the main conductor, for on it depends the operation of the road in case of accidents or repairs to the contact wire.

The arrangement of main and working conductor are as already set forth.

This main conductor is, as stated, supplied at widely separated points by feeders, which come from the main supply at the central station. Without the use of these feeders, which can also be reinforced if necessary, the size and cost of the overhead conductors would be very largely increased. The curves are formed of a series of short chords, which approximate the central line of curvature.

The current is taken from this working conductor by a light structure on top of the car. This consists of a low skeleton framework which carries an adjustable swivelling trunnion, hav-

ing at its upper end a jaw in which is suspended a counterbalanced trolley pole, having at its extension a grooved wheel held by a spring against, and making running flexible contact with, the under side of the working conductor. The flexibility of this arrangement is very great, it being able to follow with perfect facility variations of the trolley wire two or three feet in either horizontal or vertical direction at any speed, and around any curve. What is all important, it relieves the line of strain instead of adding to it. When getting at the end of the track this trolley trunnion is swung around so as to trend in a proper direction abaft the centre of the car. If off the line it can be replaced from the car quickly and easily in the darkest night. From the trolley the current passes through a protected wire to the lightning arrester and thence to two switches, one at each end of the car, whence after whatever commutation is necessary, it goes to the motor circuits, and thence to the wheel frame.

The return circuit is through the track, and thence by both metallic and ground circuits to the station. Each section of rail is joined to a copper ground wire, which runs throughout the length of the road underneath or alongside the stringer pieces, which is to prevent appreciable differences of potential existing between the rails; as a further precaution, at intervals of 500 feet this ground wire is connected to an earth plate, and at seven points widely distributed, these ground plates are supplemented by heavy iron pipes sunk into iron ore, or 12-inch water wells, about 25 feet deep. The ground wire is connected to the station, and there is also a main ground connection made there in a 30-foot well through a large sink plate, and another to the entire waterworks system. Some modifications of the overhead system are now being made which will make it impossible for any accident to one section of the line to disable the remainder; will enable the different sections to be operated independently; and, in case of a fire which may necessitate the blocking or temporary disabling of one part of the line, will allow this section of the line to be cut out of action either automatically or at will.

Each car is fitted with a duplicate and very powerful motor equipment. This is carried entirely beneath the car body, is very compact, out of sight, and necessitates no radical change in the construction of the car. The body had to be stiffened a little and three-inch steel axles put in. One of the great objections which have been met with in applying motors, whether steam, electrical or of any other character, to the propulsion of street railways, has been the difficulty of getting sufficient track adhesion to operate the car under all conditions of track, loads and grades. Especially was this objection true in Richmond, where it was manifest that no application of a motor system could be fully successful unless the entire weight of the car and its contents was made available for traction.

One of the manifest reasons is, of course, the slippery character of the track under many conditions. Another thing should also be noted, and that is that it is almost impossible in practice to cast all wheels of exactly the same circumference, or at least so that the paths described by the lines of contact shall be the same. Moreover, on curves the wheels are all traveling over paths of different lengths. Theoretically, the wheels should be independently driven, but since this is not possible it follows that the next best thing is to drive each pair of wheels independently. It is a fact which admits of no dispute that there are conditions of track which will not permit of a car being driven from one pair of wheels only, and this difficulty is often augmented by the fact that if one pair of wheels only is used they will sometimes be leading, sometimes following; on heavy grades with one platform reserved for the driver there is a very serious displacement of the centre of gravity, and there may be very much more weight upon one pair of wheels than on the other. The whole experience in Richmond has been to emphasize the value and necessity of independently driven axles.

To accomplish this, one motor is centered upon each axle, and to allow the required freedom of motion, and at the same time to preserve perfect parallelism in the meshing of the gears, and also for taking part of the weight of the motor off the body of the axle and to throw it on to the journals, one end of the motor is supported by double compression springs playing upon a loosely suspended bolt, which is supported from a cross girder in the bottom of the car.

The motors are, then, so to speak weighted or flexibly supported from the car body, and the motion of the armatures is transmitted to the axles through intermediate gearing, of compact form and great strength, so that whenever the axles are in motion there is a spring touch of the pinions upon the gears. Barring friction a single pound pressure exerted in either direction would lift or depress the motor a slight amount, and no matter how sudden the strain, whether because of a variation of load or speed, or a reversal of direction of rotation, it is impossible to strip the gears unless the steady strain exceeds the strength of the iron, the pressure on the gears always being a progressive one. The motor armature makes nearly 12 revolutions to each revolution of the car axle.

The motors, although in one sense independent, are connected with duplicate switches at either end of the car which afford simultaneous control of both machines. These motors, which are of normal capacity of 7½ h. p. each, can for a short time work up to 30 h. p., and are capable of producing a tractive effort of over 3,000 pounds at 50 per cent. efficiency.

The machines are controlled by a single movement switch which effects the various commutations and reversals. They run with fixed brushes in both directions and under all loads. They are run without any covering, and I have no doubt of having street car motors in such condition soon that the cars will be run over a pit, and the machines washed down with a hose.

The cars can be run at widely different speeds, varying from the slowest crawl to twelve or more miles per hour. They can be started and stopped without the use of brakes in the space of three or four inches, and when making the normal running speed can, in an emergency, be stopped and reversed without brakes within less than a quarter of a car length. The starting, although prompt, is easy and without shock or jar.

Emergencies sometimes bring out qualities of motors which are unexpected, or which at least if counted on are rarely ever brought into play. On one occasion a man was descending a six per cent. grade with a heavy load when his brake chain parted. Seeing a sharp curve right ahead of him which he knew he would leave if he struck it at the speed he was running, he instantly reversed his machines and brought his car to a standstill, and on the rest of his trip handled his machines entirely with the motors. On another occasion a man passing from behind one car directly in front of another was struck and knocked down by the dashboard. Although the car was moving at a lively gait, the machines were reversed and the wheels stopped within a foot of the man. By any other method of propulsion he would have been killed. Frequently on a ten per cent. grade, with a loaded car, the brakes have been thrown off, the machines reversed, the car stopped and started backward up hill within less than one-half of its length, a test of the most remarkable severity.

In noting the control of the car, one is struck at the remarkable character of the traction, and cannot help wondering where it comes from; unquestionably it is in a large measure due to the fact that every pound of weight is available for traction, and that the two axles being independently driven, can take their own speed, and each pair get the best grip.

Another thing to be noted, where the ground circuit is used, is the increase of traction due to the passage of the current from the wheels into the rails. Exactly what molecular action takes place has not been ascertained; it may be simply heating at the contact surface, but the fact remains that the traction is very largely increased. The magnetic condition of the wheels and tracks also has some function in this increase of traction. The wheels and axles are magnetized by the method of motor construction and mounting, and also by the passage of the current through them; the tracks are likewise magnetized by the current passing through them, and also by the rolling contact of the wheels. Yet, admitting all these aids, the results have been extraordinary.

Sixteen-foot closed cars carrying picked loads of fifty-five to sixty passengers, and having a total weight of 15,000 pounds are operated on the 10 per cent. grade, often with a slippery and slimy rail, and on 27-foot curves, without the use of sand or extra help.

These same grades and curves have been ascended without sand after one of the worst sleet storms which has visited this section for years. Various tests under the most unfavorable conditions have been made, cars often being required to cut their way through clay, snow and ice when the tracks were out of sight. No severer test could have been made, and the power and tractive effort developed have exceeded the most sanguine expectations.

Cars have often been stopped and started on the heaviest grades, and in the sharpest curves. One motor has propelled two cars around sharp curves and up six per cent. grades. One car has pushed another of greater weight around the sharpest curves and up seven and eight per cent. grades both straight and combined.

I have no hesitation in saying that with a clean track, and with proper gearing, these cars could mount a 15 per cent. grade, depending on adhesion alone. During the four months operation, although there have been troubles and changes have been made while the cars were running commercially, no car has been pulled a foot by animal power; if any accident has occured to a motor the car has gone along with one machine, oftentimes with heavy loads and on heavy grades, or in some cases has gone home in company with another car. One-hundred-and-forty men who did not know the difference between a motor and a hand saw, have been broken in to handling these cars; oftentimes with remarkably short training. Up to Saturday, May 12, the number of regular cars on duty had not exceeded twenty. On that day at 4 P. M., the hour when traffic becomes exceptionally heavy, we began putting out ten open cars, starting them from the eastern car house alternating with the closed cars, but finally banking them all up at the Old Reservoir. At 6 P. M. they were started home, and shortly afterwards these ten open cars, headed by a closed car, were all run at full speed close together down the east-bound track of Clay street. At one time fourteen cars were on the line between Clay and Hancock streets and the Old Reservoir, and shortly before

7 o'clock there were about twenty-two cars on the line between Capitol square and the Old Reservoir, and at 7 o'clock thirty cars were on the line, the closed cars being very heavily loaded, many

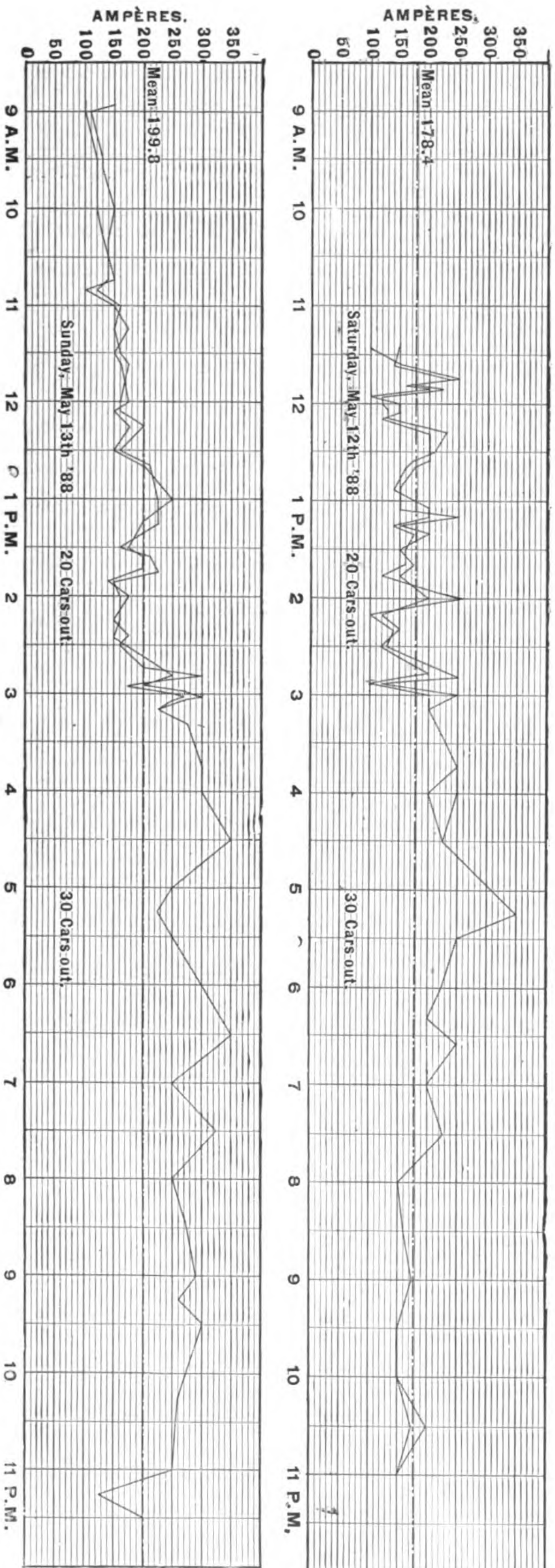


FIG. 3.—Ampere Diagrams, 20 and 30 Cars on Track.

of the cars being run with two minutes interval. The three boilers, whose capacity is 375 h. p., were then supplying three Armington & Sims engines of 125 h. p. capacity, which were driving the six railroad dynamos, and two Westinghouse engines of 110 h. p. capacity, which were driving two alternating current dynamos and exciters with an equivalent load of 1,060 incandescent lamps. The mixture was enriched and the firing of boilers became pretty active, there being in addition to the thirty cars badly banked about 110 h. p. taken for lighting.

The highest reading (Fig 3), however, on the line was less than three-quarters of the normal capacity of the dynamos, which were originally intended only for thirty cars, and the average reading for this number was only a trifle over half the normal capacity. Most effective work was done by the automatic steam regulator as was shown by the steam diagram for the same day.

The ampere readings taken at intervals of ten and fifteen minutes give a load diagram, which is really higher than a continuously recording instrument would show.

The figures which follow, being based upon an actual service increasing from eight to thirty cars, and extending over a period of four months under the most trying circumstances, and at the most critical and care-requiring period of the enterprise's existence, will give street railway men the most careful and liberal estimate of every possible expense attending the operation of the road which is in any way dependent upon its electrical features. The operating expenses are given under two heads; first, the central station operating expenses, and second, the road operating expenses, the two constituting the total cost of motive power. These are given in detail, and they will probably be found to cover every expense, although in some small ways the distribution of these expenses may be found to be changed by several months longer running. The fuel and other incidental expenses of the station are from the engineer's record, and checked by the readings of the electrical instruments.

For thirty cars running on a double track the central station expenses are about as follows:

52 42-100 cwt. coal, at 10 cents	$5.84	
113 70-100 cwt. screenings, at 7 cents	7.96	
5 pints cylinder oil, at 75 cents per gal.	.47	
5 pints dynamo oil, at 30 cents per gal.	.18	
8 pounds waste, at 10 cents	.30	
Water at current rates	3.00	
Fuel, etc.		$17.75
1 day engineer	$3.00	
1 night engineer	2.25	
4 firemen	6.00	
1 cleaner	1.50	
2 dynamo men	3.50	
1 electrician	4.00	
Labor		$20.25
Lighting		.50
Depreciation and repairs on dynamos, 3 per cent.		1.50
Depreciation and repairs on engine and boilers 10 per cent.		4.38
Total central station expenses		$44.38

Or $1.48 per car making 80 miles.

[The central station being operated for twenty-fours for lighting and power purposes, the lighting company has now assumed charge and rents the power to the cars at $1.60 per day.]

In estimating the road expenses more than liberal allowance is made, but in a new enterprise it is safe to err on this side rather than attempt to claim for a system advantages which will not in practice be borne out. The expenses are then as follows:

Oil, grease and waste	$4.50	
Brushes	3.00	
Trolleys	2.00	
Material		$9.50
Three mechanics and one helper for thoroughly overhauling motors once a week, making repairs, adjusting brakes, etc.	7.90	
Four inspectors, two day and two night, for oiling machines and looking after brushes	7.50	
Two night inspectors to thoroughly inspect motors after cars are laid up and see that all bolts, nuts and connections are tight and that everything is in good working order for the morning run	4.00	
One winder and helper for making any repairs which may be necessary and any testing which is required	3.50	
Two linemen	5.00	
Labor		$27.90
Depreciation on car work at 15 per cent.	18.00	
Depreciation on line work at 10 per cent.	4.00	
Depreciation		22.00
Total road operating expenses		$59.40

or $1.98 per car making 80 miles.

The total motive power expenses both in the central station and out on the road would not then exceed $3.46 per car making 80 miles, or 4.32 cents per car mile, and this includes everything except the executive and salary expenses, taxes and insurance, and is less than 40 per cent. of the cost of operation by horses with the same number of cars, and under the same conditions.

But the showing is even better than this, for another fact is to be noticed, and it is an important one from an economical point of view. For example, 20 cars on duty for about 18 hours make a mileage of from 1,500 to 1,800 per day, and if it were not for the

fact that the schedule requires them to operate part of the time on a single track with insufficient turn-outs they could make 1,800 or 1,900 steadily. This, notwithstanding the fact that the speed is limited by municipal regulations. Many of the cars often run 90 to 100 miles. The same mileage and intervals made by 20 electric cars could not, under the circumstances, be made by anything less than 25 horse-cars of the same size, and the electric cars probably carry in the aggregate just as many passengers. It follows that to get the same service with horses not only would the number of cars have to be increased, but likewise the number of horses, conductors and drivers. The same mileage performed by horses without these cars and grades would require a stable equipment of not less than 300 horses.

A good idea of the operation of the system may be obtained from the following weekly table, taken from the records of the railway company up to the present date :

Week ending.	No. of cars put out for regular service.	Average No. of cars out per day.	Miles per week.	Avg. miles per day.	Avg. miles per car per day.	Passengers per week.	Average passengers per day.
Feb. 8	72	10.3	2,632	376	36.5	18,764	2,680
" 15	48	6.9	1,211	173	25.2	6,688	956
" 22	77	1.0	2,604	372	33.6	16,504	2,358
" 29	91	13.0	4,039	577	44.4	21,944	3,135
Mar. 7	99	13.7	5,047	721	52.6	25,063	3,580
" 14	86	12.3	5,313	759	61.8	20,897	2,985
" 21	94	14.1	6,916	988	69.9	30,357	4,337
" 28	113	16 1	8,621	1,232	76.3	27,076	3,868
April 4	118	16.9	8,351	1,193	70.8	28,260	4,037
" 11	133	19.0	10,089	1,441	75.9	36,683	5,240
" 18	133	19.0	10,583	1,512	79.6	40,090	5,727
" 25	135	19.3	10,895	1,557	80.7	39,040	5,577
May 2	137	19.6	11,309	1,616	82.4	45,350	6,479
" 9	140	20.0	10,832	1,548	77.4	51,648	7,378
" 16	176	25.1	11,563	1,652	65.8	58,598	8,371
" 23	186	26.6	12,128	1,733	65 2	55,163	7,880
" 30	194	27.7	12,789	1,830	66.1	57,519	8,217
June 5	189	27.0	14,154	2,022	74.9	52,820	7,546
" 13	187	26.7	14,649	2,093	78.4	59,219	8,459
" 20	181	25.9	14,371	2,053	79.2	70,965	10,138
Total	...	....	178,096	.....	....	762,648	......

With the mileage which is now made, there is an actual saving of about $125 per day in the motive power expenses as against operation by horses. It is hardly necessary to point out that this would pay a good interest on a pretty large investment. The capacity of the road to economically carry passengers has been made so apparent that the old city railway, which was operated by mules and has about 13 miles of track and 50 cars, has been bought up and is to be equipped with motors operated from the same central station. A third line will probably be added, and in the near future every street car, to the number of 100, in Richmond and Manchester will be electrically operated from one station.

From this same station is operated a power and light circuit.

Having thus seen what is possible on a street railway, let us briefly consider the application of electricity on a larger scale.

The failure of the elevated railroads in this city to meet the issue of rapid transit is in no way more forcibly illustrated than by the number of plans which have been brought forward for discussion. No less than 11 have presented themselves, several of which have features in common and claim similar routes; and I will but very briefly review them.

The Beach Pneumatic was merged into the Broadway Underground, and this in turn into the New York Arcade Railway Co., and it is now familiarly known as the Arcade. They propose to run from the Battery, thence to Broadway and Madison square, with four tracks, the two centre being express tracks, with stations one mile apart, and the two outer tracks for way traffic. Thence the route extends to 59th street by Broadway, and to the Harlem river by Madison avenue, with an additional route up the west side of Central park by the Boulevard or some other avenue, and into the annexed districts. Branches are proposed to connect Broadway and Madison avenue on 23d street, and the two branch roads on 42d street.

The Underground Railway Construction Co. has pooled the issues of the New York District, New York Underground and the Metropolitan Junction companies. The route of the first is similar to that of the Arcade, and runs from the Battery to Broadway and Madison square with four tracks; thence up Broadway to 59th street, and up Madison avenue over the Harlem river to some point near Jerome park. Branches are also proposed from river to river on 12th and 23d streets. The New York Underground road propose to run from the City Hall park east to Broadway, through Centre and Mulberry streets to Lafayette place and 4th avenue at Union square. Thence by two lines to the Grand Central, and Broadway and 59th street, up the Boulevard to Kingsbridge, the main line continuing under Madison avenue to the Harlem river and by a loop to Kingsbridge.

The Metropolitan Junction Co. proposes to connect with the two last named in the annexed districts, and then run over the Hudson by a bridge at Washington Heights, connecting with a tunnel through the palisades.

The City Railway Co. proposes to begin at South and Whitehall streets, crossing Broadway below Rector, running between Church street and College place, 6th and 7th avenues to 59th street and the Boulevard. The line would then run up the west side of Central park, crossing the Harlem river above High bridge, terminating in New Rochelle. Branches are proposed for the principal ferries on both rivers, the post office and Grand Central station. The roadway is intended to be 50 feet wide and 12 feet below the street surface; it is to have four tracks, two way and two express. It differs from the other underground railways in that instead of taking the street lines it proposes to purchase the necessary property and erect buildings over the line of the road, which are to be rented for sufficient to pay the bonds of the company. The road thus running through the basements, so to speak, of the buildings, and crossing the streets by tunnels, becomes a covered roadway instead of an open one.

The Terminal Underground Railway Co. proposes a four-track underground railway from the City Hall along the proposed Elm street improvement to the Grand Central depot.

The Metropolitan Transit Company proposes two elevated steel structures, one on Broadway, between Chambers street and Forty-third street, connecting with the Grand Central Depot, and the other on the West Side, following the line of the water front to Gansevoort Market, thence up Tenth avenue and the Boulevard to Kingsbridge.

The plan proposed by Heman Clark is one of the most radical. He proposes a four-track tunnel, beginning near Fleetwood Park, cut in solid rock 150 feet below the surface, coming down about 100 feet west of the line of Broadway to the Astor House, where it would connect with two two-track branches, one going under the North River to Jersey City and Newark, and the other under the East River to Brooklyn and Prospect Park. Passenger stations would be at the foot of shafts, sunk every two miles, and freight stations at intermediate shafts, where freight pockets would be tunneled. Large elevators would be used for handling the passengers and freight.

All of these schemes have their good and bad points which I do not propose to here discuss; but whichever is successful, they hope to use electric motors for propulsion. Now, whatever we may claim for electrical motors, it would be folly to attempt the handling of the traffic of such a road without full knowledge as to the character of the work which has to be performed and a perfectly definite idea of the system of train despatching which will best meet the wants of the public and, at the same time, preserve an effective and economical system of operation. To fully consider this let us briefly review the work which is being done on the elevated railroads, for example on the Third avenue line.

This is eight and a half miles long. Grades vary from eight to one hundred and five feet to the mile. The level stretches amount to about one-third of the whole distance, and this includes the stations. On the seventeen miles of single track there are fifty-two stations. In the busy hours there are no less than sixty-three, four and five-car trains on the tracks. These trains, weighing from eighty to ninety-five tons, make the half trip in forty-two minutes, including stopping at twenty-six stations and discharging and taking on passengers, or at the rate of about ten traffic miles per hour. The work of the engines may be divided into three parts; overcoming the train's inertia, lifting the train on the grades and traction; and the maximum is at least seven times that necessary for traction at mean speed on a level. Three times in every mile this weight of 80 to 95 tons must be started from a dead rest, raised to a speed of twenty or more miles an hour and brought to rest in about eighty seconds. The engines have to be run with 130 pounds boiler pressure, and have a capacity of 185 h. p. Fifty-nine per cent. of the power on a round trip is used in starting, 24 per cent. in lifting, and 17 per cent. in traction, and the average power developed per minute per round trip, including stoppages, is 70.3 h. p.

The traction necessary to handle these trains is obtained by a locomotive weighing 22½ tons, of which only 15 are carried by drivers five feet apart. With an engine and the forward trucks of one car between two girders, we have a weight of nearly 1,500 pounds per running foot. The present weight of engines is not sufficient to properly handle these trains when the tracks are in a slippery condition, and it is not wise to increase it. It is absolutely necessary to keep up the high character of the engineering work of this road, and every consideration of business, prudence and public safety will permit of no laxity in this direction. Yet these locomotives have done wonderful work. Although on duty for twenty hours, with steam admitted to the cylinder for six hours only, with an average horse-power of only 38 per cent. of the maximum, and with all the incidental losses of steam, they develop a horse-power with less than a total expenditure of 6.2 pounds of coal per hour; and the coal expense alone is only about $1.15 per round trip, or 2⅛ cents per train station. The operating expenses are 62 cents per train mile; or, allowing an average of four cars per train, 15½ cents per car mile; and this includes everything.

The percentage of expenses of operation and maintenance for the whole Manhattan system may be roughly expressed as follows:—

Motive power	42.8
Maintenance of cars	5.4
Movement of traffic	38.4
Maintenance of way	8.2
General expenses	7.2
Total	100.0

The coal alone costs over $700,000 per annum, which is more than the wages of the engineers and firemen, but it is only about one-sixth of the total operating expenses. Hence there are other reasons than merely a saving in coal which must be urged in favor of an electric system as against a steam system.

Generally speaking, the real needs of rapid transit are not best subserved by the handling of long trains from a single tractive engine. True, the conditions of service on the elevated railroad, the crowded condition of the track, and the great cost of operating independent steam engines makes it impracticable to work with small train units there. But the fact remains that the effective length of train which can be operated by any system is limited; that this limit has already been reached on the elevated railroad, where only one-sixth of the weight is now effective for traction; and that the smaller the units the less the momentum of the train and the easier it is to quickly and efficiently handle it, and the less will be the liability of, and danger from, any derangement of the brake apparatus. Furthermore, the thrust of the moving weights on the grades, the vibration due to the shifting of the weight along the girders, the tensile, shearing and crushing strains on the structure are all materially increased by the use of a heavy locomotive at the head of a long train.

But since we must endeavor to meet all conditions of engineering, we must try to meet that one which requires the operation of a heavy train by a single motor car. In this case I deem it advisable to make the motor car of about the same size as the cars which form the train, equip both trucks and thus spread the weight used for tractive purposes over a larger distance. We have now partly constructed a 300 h. p. motor equipment of this character.

This car, whose general external dimensions are similar to those of the regular elevated passenger coach, differs in its construction in many important details. The front and rear platforms are inclosed, and about ten feet at each end of the car—that is, the space over the trucks—is partitioned off and reserved for the use of the motor man. The middle space has side entrances, and is fitted for passenger accommodation. At each end of the car the floor framing is raised about twelve inches for a distance of about ten feet from the end, and the car body is carried on two very strong and heavy special iron trucks mounted on forty-two-inch wheels fitted with five-inch steel axles. Each axle has an independent movement and is driven by a tandem motor, centred upon the axle, which bears a part of the weight. The motor is also carried by heavy compression springs hung from the truck, by means of which as much of the weight of the motor as is desired can be thrown onto the boxes. Each motor, which is of about 75 h. p. normal capacity, has two armatures, each of which is connected to a fixed and adjustable gear on the axle, the ratio of the gearing being about 1 to 3. These motors will have one brush on each commutator, and that will be a top brush. Each motor has directly over it, in the engineer's room, trap-doors fitted with heavy glass panels, which allow the machines to be seen at all times, and through which the machines can always be reached. The controlling devices and switches are all duplicates, and the car can be handled from either end. The car and the trucks are completed; the motors are well under way. The car will be capable of exerting a tractive strain of at least 20,000 pounds—more than double that of the present locomotives.

But this is not the ideal method of traction.

By a system of electrical propulsion, the power can be distributed underneath the cars, every car, or every two cars if need be, being a unit; and, although I do not think it advisable, arrangements could be made for propelling a large number of cars under simultaneous control. By distributing the power under the car, the whole weight of the car and passengers can be made effective for traction. This will enable the cars to be started more promptly, brought to speed more quickly, and stopped in shorter intervals, increasing the mean rate of speed for a given maximum, or vice versa, reducing the maximum for a given mean rate. By making cars individual units of locomotion, the intervals between trains may be made one-fourth or one-fifth of the schedule which must exist where four or five-car trains are used. It may be said that this will increase the number of employés that are necessary. This is true; but it will increase the number of passengers who, both day and night, would make use of the system, in such a ratio as would make this increase of expense insignificant.

Let us consider a possible system which would go a long ways towards solving the question of rapid transit. I will briefly point out its features. It would have four tracks extending from the battery up Broadway to twenty-third street; thence diverging in two divisions, each still with four tracks, one along the line of Madison avenue to the Harlem river and terminating near the Jerome park district; the other following Broadway and running up the line of the Boulevard and Tenth or Eleventh avenues. Two tracks would be reserved for express traffic, with stations a mile apart, and two for way traffic, with stations every third of a mile, every third way station corresponding with an express station. The tracks would be arranged in two tiers, the express tracks being the lower. The entire system would be lighted, ventilated and operated by electricity, to be supplied from four stations on the water front, one at the Battery, one at East Twenty-third street, one at Madison avenue crossing of the Harlem river, and one on West One Hundred and Twenty-fifth street; the stations to be operated by compound condensing engines in three units connecting directly to large, slow moving multipolar dynamos, two engines being of sufficient capacity to handle the demand made upon any station; trains to be operated with one or at most two car units; motors to be on the trucks of one car, centred on the axle and with one reduction of gearing; express speed to be thirty miles an hour, and way trains to make twelve traffic miles per hour; the current to be delivered to the cars by an overhead system with underneath contact, the contact wheel to be carried on the car, supported over the centre of the truck and trending a little abaft it. Freight pockets at the level of the way track could be run under the cross streets at express stations. Track to follow a line of grade of not more than 25 per cent.; access to stations to be by stairways, and where there is any material difference between the street level and the track, by hydraulic elevators, operated from constant pressure tanks kept supplied automatically by motors. Freight trains to be run on way tracks.

Supplementing this system should be a line of surface cars, likewise operated by electricity from the same general source. In the heart of the city these can be operated from a conduit, or by the storage battery, and in all the suburban extensions by the overhead line system.

The objection of loss in transmission and recovery has been raised as against an electric system, and also the question of braking. These are easily met.

We have systems of electrical braking a train by the use of its motors, which consists in converting them into dynamos, deriving their driving power from the train, and using up its energy by converting it into electrical energy, which can be used in a variety of ways. In a storage battery system the energy of the car can be made to partially recharge the batteries on a down grade and in stopping. In a direct supply multiple arc system, operating a large number of cars, this power of at will being able to convert the energy of a moving train into electrical energy delivered to the line by the same apparatus which controls the speed and power of the train is of exceptionable importance. In a double track system, the energy given to one track may be communicated to the other just as efficiently as along itself. In fact, in the entire electrical system, every part is mutually connected, and there is a bond of union between the different trains far more perfect and effective than any mechanical connection could be. The up-grades on one track being equal to the down-grades of the other, it is evident that the total up-grade of a system is equalized by the down-grade thereof. If, then, energy is expended in getting under way and climbing up-grades, and a large proportion of this can be recovered in stopping and in running down-grade, it is evident that the total initial energy required would be that necessary to move the trains continuously on level grades, with a percentage for loss in conversion and reconversion added. The more train units which are operated, and the more frequent the stoppages, the more marked is this advantage in an electric system.

I some time since made a number of determinations of a system of the equipment capacity of the Third avenue elevated, in which I found that about 40 per cent. of the power could be saved by this system of braking, where every motor coming to a station or running of a down-grade is made a generator which is helping to supply the current needed to operate the remaining trains.

Instead of the current being all supplied by a main generating station at one or two points, it would be supplied from nearly as many moving stations along the line as there would be trains slowing down or running on a down-grade. In fact, the loss of the two conversions and one transmission would be more than counter-balanced, and consequently the original horse-power at the central station would be no more than the aggregate net horse-power now developed on the entire line, and this is only about 38 per cent. of the total capacity of the engines. With any given potential and losses on the line, the main conductor would be very much smaller. Not only on the line, but at the central station would a saving be effected; for in a system of the capacity of that which we are considering this saving on lots, buildings, boilers, engines, dynamos and fittings would be not less than $400,000, and there would be about 40 per cent. saving in the coal, labor, depreciation and incidental expenses of the central station.

Another method of using the motors for braking purposes is to break the connection from the line and reverse the machine through a local circuit on the train, varying either the local circuit or the circuits of the machine. While in this position of braking, if the local circuit is opened and the line connection made, the machine would be instantly reversed.

Elaborate experiments were made by me nearly two years ago on the Thirty-fourth street branch of the New York Elevated Railroad, in which these questions of gearing, of mounting the motors on trucks under the car, and handling the car without shoe-brakes were very thoroughly studied. There, this method of braking was shown to be under the most perfect control. When desired, the braking could be made so sudden as to cause the wheels to have a continuous skidding rotation, not such a skidding as is caused when an air brake is put on too sharply, but a rotating slip which is just enough to relieve the armature when the strain on it reaches the point determined by the coefficient of adhesion on the rails.

This is the ideal method of braking, because fixed skidding and flat wheels are an impossibility, and the wheels will turn until the train comes to a dead stop, although, where the braking power is put on too suddenly and exceeds the grip of the wheels, they will relieve themselves by slipping just enough to keep the braking at the maximum limit. A train so governed can be made to creep down the maximum grade of a road at a snail's pace, and in an emergency such a car, running 21 miles an hour on a down grade, has been stopped and reversed within 90 feet.

When an electric motor is reversed its action is cumulative, for so long as its motion continues in its normal direction, it tends to augment the current which flows through it with any given setting of the switch, and thus very much increases the effort to stop itself; and the higher the velocity at which the armature is traveling, the greater this effort. In fact, it would be practically impossible with a properly constructed railroad motor to prevent its reversing when the switch is thrown over far enough. This is another point in which an electric motor has a great advantage over a steam engine.

So it would seem that electricity has practical advantages over steam for this character of traffic, and there are considerations other than purely engineering ones. The use of electricity instead of steam would do much towards making a road of this character popular. We would have express and way trains, starting and stopping smoothly and quickly, moving at a high rate of speed and running at short intervals. Dust, smoke, cinders, oil and drippings would disappear; the air would be purer and cleaner. The trains would be safer and under more perfect control; motive power would cost less; depreciation on the track structure would be much less; the carrying capacity would be increased; cars would be brilliantly lighted; comfortably heated; in short, everything which would make rapid transit safe, pleasant and effective is possible by a properly developed system of electric traction.

One of the most important sources of revenue from such a system would be the sale of power for stationary purposes. Already we are operating no less than 130 different industries by electric motors, and the receipts vary from $60 to $150 per horse-power. The extent of the application of electricity with any such general source of supply can hardly be conceived. Its profits would be far more than enough to pay the total cost of motive power.

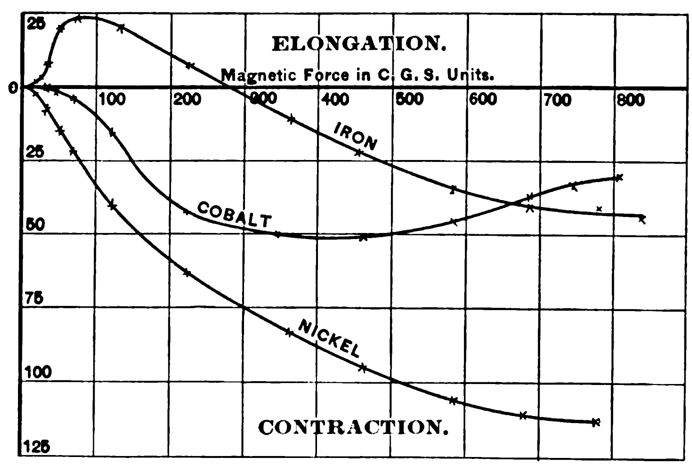
But we must not shut our eyes to the work which has got to be done. We must not exaggerate the advantages of electricity; we must not belittle the position of a system which has been developed by the ablest engineers for the last forty years. All their experience, all their study, all their victories form a magnificent groundwork for us to build upon, and will render the final victory of electricity more easy and certain if we build wisely and take to heart all the lessons which their years of experience teach us. In a small fraction of the forty years which have marked the development of steam engineering, electric engines will rival in mechanical perfection, in construction and performance, the best locomotives. Even to-day, weight for weight, and duty for duty, the electric motor is already rivaling and outstripping its predecessor. For the present, and for a long time to come, it is probable that for trunk line work, and for the original source of our power in an electrical system, we will be dependent upon the steam engine; but we all hope and expect that the future will bring us some other effective means of converting the energy of coal into electrical energy, and that by some direct method which will not require the intervention of a steam engine and dynamo. It is not too much to hope for, and already experiments have been made which foreshadow this great result. The success of this discovery would produce such a revolution in the use and distribution of power as to exceed our most sanguine expectations.

.... I CERTAINLY think there is a field for alternating motors, and there is undoubtedly an opportunity for obtaining motors which possess even some advantages over the continuous current motors.—*Elihu Thomson.*

ABSTRACTS AND EXTRACTS.

THE ELONGATION AND CONTRACTION OF METALS IN MAGNETIC FIELDS.

IT has long been known that a bar of iron when magnetized by a surrounding solenoid alters its length, and with the weak magnetizing forces which were originally employed in these experiments, the alteration was invariably an increase in length. One of the earliest experimenters, and probably the original discoverer of this behavior of iron when magnetized, was Joule; but he invariably found that the length increases with the magnetizing force. In his experiments, however, the magnetizing force did not exceed 87 C. G. S. units, and an ingenious theory was propounded to show that elongation must take place when a bar of iron is magnetized. It was believed that the molecules as they rotate under the influence of the lines of force, and become more or less parallel, naturally require more room in the direction of the length of the rod, and therefore cause the latter to extend with a corresponding decrease of diameter. This simple explanation was refuted by the experiments of Mr. Shelford Bidwell, which he made some years ago, and in a paper communicated by him to the Royal Society in 1885, he showed that the elongation does not remain unchanged at its maximum when the magnetizing force exceeds that which is sufficient to produce so-called saturation; but, on the contrary that with increasing magnetizing forces beyond this limit the elongation becomes less until the rod, after returning to its original length, ultimately becomes actually shorter than it was in the unmagnetized condition. Mr. Shelford Bidwell has, however, recently contributed to the Royal Society, another paper on the same subject, and in this he points out that his original investigations might be open to the following objections: (1) The field due to the magnetizing solenoid was not



quite uniform; (2) the effect of the ends of the rods was uncertain, and might have played some material part in the production of the phenomena in question; (3) all the rods used in the experiments retained a certain amount of permanent magnetism. To meet these objections he has carried out a further series of experiments by using rings instead of rods of iron, and observing the changes of diameter. The rings were also demagnetized before every observation, and the battery employed was much stronger than that used in the first experiments, so as to produce very great magnetizing forces. He found that in their general character the phenomena of elongation and contraction were the same with rings and with straight bars, thus proving that the effect of magnetization was independent of the form of the iron, and as it was much easier to obtain intense fields with straight than with circular solenoids, the author made some further experiments with straight rods. These experiments embraced iron, cobalt, nickel, manganese steel, and bismuth, and the highest magnetizing force reached was 840 C. G. S. units. We are able, by the courtesy of Mr. Shelford Bidwell, to publish herewith a diagram showing the behavior of iron, cobalt, and nickel in magnetic fields of varying intensity. The strength of field is plotted on the horizontal, and the change of length in ten millionths of the original length of the rod is plotted on the vertical, the elongations being plotted above, and contractions below, the axis. The line of bismuth, which metal was tested in fields varying from 500 to 840 units, almost coincides with the axis, and manganese steel was also found to be almost unaffected, the elongation in a field of 850 units being only about one-fifty millionth of the length. That the change of length in the other metals which are sensibly affected by magnetization cannot be due to the mechanical stress produced by magnetic attraction between

the ends of the bar, is shown by the author in the case of iron where mechanical stress does not account for more than one-fifths part of the observed magnetic contraction. It should also be remembered that up to a magnetizing force of 280 units, iron elongates, and, therefore, the mechanical stress in iron opposes magnetic extension.—*Industries.*

EFFECTS OF DIFFERENT POSITIVE METALS, ETC., UPON THE CHANGES OF POTENTIAL OF VOLTAIC COUPLES.[1]

BY DR. G. GORE, F.R.S.

In this research numerous measurements were made, and are given in a series of tables, of the effects upon the minimum point of change of potential of a voltaic couple in distilled water (Roy. Soc. Proc., June 14, 1888), and upon the changes of electromotive force attending variations of strength of its exciting liquid (*ibid*), obtained by varying the kind of positive and of negative metal of the couple, and by employing different galvanometers. The measurements were made by the method of balance through a galvanometer, with the aid of a suitable thermo-electric pile (Birmingham Philos. Soc. Proc., vol. iv., p. 130. *The Electrician*, 1884, vol. xi, p. 414.) The kinds of galvanometer employed were an ordinary astatic one of 100 ohms resistance and a Thomson's reflecting one of 3040 ohms resistance.

The following were the proportions of hydrochloric acid (hcl) required to change the potential of different couples in water:—

TABLE I.—HYDROCHLORIC ACID,

Couples.	Astatic galvanometer.					Reflecting galvanometer.				
Zn + Pt	Between	1 in	9,300,000	and	9,888,185.	Between	1 in	15,500.000	and	23,250,000
Cd + Pt	"	1 "	574,000	"	637.000.	"	1 "	1,162,500	"	1,550,000
Mg + Pt	"	1 "	516,666	"	574,000.	"	1 "	775,000	"	930,000
Al + Pt	"	1 "	12,109	"	15,000.	"	1 "	42,568	"	46,500

With iodine and the astatic galvanometer the following proportions were required :—

TABLE II.—IODINE.

Zn + Pt.	Between	1 in	3,100,000	and	3,521,970
Mg + Pt.	"	1 "	377,711	"	643,153
Cd + Pt.	"	1 "	200,431	"	224,637

With bromine and the astatic galvanometer:—

TABLE III.—BROMINE.

Mg + Pt.	Between	1 in	310,000.000	and	344,444,444
Zn + Pt.	"	1 "	77,500,000	"	84,545,000
Cd + Pt.	"	1 "	3,470,112	"	3,875,000

The magnitudes of the minimum proportions of bromine required to change the potentials of the three couples in water, varied directly as the atomic weights of the three positive metals.

With chlorine the following were the minimum proportions required:—

TABLE IV.—CHLORINE.

With the reflecting galvanometer.

Mg + Pt. Between 1 in 27,062,000,000 and 32,291,000,000

With the astatic galvanometer.

Mg + Pt.	Between	1 in	17,000,000,000	and	17,612,000,000
Zn + Pt	"	1 "	1,264,000,000	"	1,300.000,000
Zn + Au	"	1 "	518,587,360	"	550,513,022
Cd + Pt	"	1 "	8,733,585	"	9,270.833
Zn + Cd	"	1 "	55,436	"	76,467

In the case of chlorine, as well as that of bromine, the magnitudes of the minimum proportions of substance required to change the potential of magnesium-platinum, zinc-platinum, and cadmium-platinum varied directly as the atomic weights of the positive metals.

The examples contained in the paper show that the proportion of the same exciting liquid necessary to disturb the potential of a voltaic couple in water varied with each different positive or negative metal, and that the more positive, or more easily corroded the positive metal, or the more negative and less easily corroded the negative one; the smaller usually was the minimum proportion of dissolved substance necessary to change the potential.

By plotting the results in all cases, it was found that the order of change of potential caused by uniform change of strength of liquid, varied with each positive metal.

The results also show that the degree of sensitiveness of the arrangement for detecting the minimum point of change of potential depends largely upon the kind of galvanometer employed.

As a more sensitive galvanometer enables us to detect a change of potential caused by a much smaller proportion of material, and as the proportion of substance capable of detection is smaller the greater the free chemical of each of the uniting bodies (Roy. Soc. Proc., June 14, 1888), it is probable that the electromotive force really begins to change with the very smallest addition of the substance, and might be detected if our means of detection were sufficiently sensitive, or the free chemical energy of the uniting bodies was sufficiently strong.

1. Read before the Royal Society, June 21, 1888. Abstract.

POINTERS.

.... I THINK we are well within the mark when we say that we can maintain accumulators for 12½ per cent.—*R. E. Crompton.*

.... THERE is no doubt that iron in the armature is the essential feature of a good alternating dynamo.—*Professor George Forbes.*

.... IN any properly engineered railway plant, the electrical pressure should not vary 10 per cent. in any part of the circuit. —*F. J. Sprague.*

.... THE regulation series system in its different classes, single and multiple series, has been the ignis-fatuus of electricians in incandescent lighting.—*F. J. Sprague.*

.... IT is found most positively that the return of the Westinghouse transformers is more than 600 kilo-watts in the lamp for the indicated horse-power.—*Professor George Forbes.*

.... THE Americans like mud...... In some towns arc lights are hoisted on poles some hundreds of feet high; this is no doubt a frantic effort to get clear of the mud.—*Swinburne and Sellon.*

... THERE is far too general an idea that electrical engineering is a genteel profession, and that a man can get on well in it without soiling his hands. This is a mistake.—*Electrical Engineer* (London).

.... THAT is, 80 per cent. of the indicated horse-power in the cylinder of the steam engine in effective horse-power at the terminals of the lamps. Never was such a monstrous statement made.—*R. E. Crompton.*

.... A YELLOW incandescent wire flickering in a finger-glass at the end of a gibbet—hardly equal to those sold at a shilling a box, known as Price's patent night lights.—*Councillor Crowther Davis, of Leamington, England.*

.... WE find actually that aluminum is really capable of giving an electromotive force less than zinc ; so that it would seem as though by the proper use of zinc in some way or other we might separate aluminum.—*Elihu Thomson.*

.... WHEREVER overhead wiring can be used I have no doubt that distribution by means of alternating current transformers is a very good system to use, and probably is considerably cheaper than that by batteries.—*R. E. Crompton.*

.... THE scientific method of investigating historical events has shown us how false, how childish, is the "great man" theory of history...... But if the great man theory of history is fallacious, so is the great man theory of inventions.—*Silvanus P. Thompson.*

.... IN the few months I have been studying the alternating system in America, I have gained more practical information than I could have obtained from reading the papers of all the authors who have written in this country on the subject.—*Professor George Forbes.*

.... Do not be fooled because a two-horse motor can do five horse-power. It is a beautiful thing to show a customer, but when you put a meter on the circuit you will feel sad when you find the small amount of money you are getting for the power used.—*Frank J. Sprague.*

.... THE chief difference between American and English practice is to be found outside the station. The American machinery is all very well made in the first place, and it is well managed and well looked after in the station, but the outside installation work is very terrible.—*Swinburne and Sellon.*

.... THE man who knows a lot about curves and formulæ and book learning generally, is not worth a d—ump if he cannot handle a hammer, screwdriver or soldering-iron, and is afraid to tackle any difficulty out of which he cannot see his way with mathematical accuracy.—*Electrical Engineer* (London).

.... THOUGH there is nothing that requires such accuracy and rapid handling as a great gun in a seaway, there is no other engine capable of such accurate and rapid work as an electric motor ; its advantages over steam, hydraulic and pneumatic engines are so marked that it would be idle to compare them.—*Lieutenant Bradley A. Fiske.*

.... As to the opinion of certain English scientists on the question of saving in the first cost of the three-wire system over the two wire, it has been frequently stated that the maximum saving of the three-wire system is 25 per cent. and that any further saving in copper beyond that was altogether chimerical. The fact is that the saving is 66 per cent.—*H. Ward Leonard.*

CORRESPONDENCE.

NEW YORK AND VICINITY.

The Underground Litigation.—End of the Cable War.—The Phonograph and the Graphophone make Peace.—Rumored Disaffection among the Operators.—A Lamp Trimmer Killed by the Current.—An Aerial Cable on Fire.—Amateur Telephones Suppressed by Law.

THE subway litigation promises to be a bonanza for the lawyers, as different suits are now springing up which promise to be both interesting and expensive. Commissioner Gibbens is fairly on the warpath, and has made a pilgrimage to the state capitol with a gripsack full of affidavits, and other documents, as ammunition with which to undertake the total demolition of the United States Illuminating Co. The examination before Justice Gorman of the Essex Market Police Court, on July 19th, was upon the complaint of expert Wheeler in behalf of the board, in which the charge is made that the wires of the U. S. Illuminating Co., not being properly insulated, and traversed by a deadly current, are a menace to human life. The defense was, as has already been intimated, that the subways provided under direction of the board are not suitable for the reception of electric light wires

The settlement of the cable war, which has continued for about two years, will no doubt put an end to struggles of that character in ocean telegraphy for some time to come. The low rate has prevailed long enough to decide that cheap cabling is not a financial success. The new rate of 25 cents per word, which is to go into effect August 1, will be continued if it proves more satisfactory to the companies than a higher rate.

The consolidation of the rival interests of the phonograph and graphophone appear to have been finally effected, and Mr. Jesse H. Lippincott, of New York and Pittsburgh, has secured control of the business management of the enterprise, which is expected to be of great importance.

The daily papers have given considerable space to speculation on the probability of another strike among the operators of the Western Union Telegraph Co. It had no other foundation than the fact that the officers of the Brotherhood were showing a little more activity than usual in securing recruits for their organization. They hope to make it strong enough to secure a hearing for their case, whenever they choose to present it. As this necessarily involves recognition of the order, it seems doubtful if it can ever be obtained under the present management, without another bitter struggle for the supremacy, and neither side is at all anxious for a third trial of strength. That will doubtless be left for another generation, unless it should be considered expedient to draw the telegraphers into a fight started by other parties; which hardly seems probable.

William Maier, a lamp trimmer, employed by the Adams Express Co. at 59 Broadway, was found dead upon the floor between two dynamos on the afternoon of July 17th. It was not at first supposed that he had been killed by the electric current, but an autopsy held on the following day proved that such was the case. He left a wife and eight children, one of whom stated that he was troubled with an affection of the heart.

During the heavy shower Thursday night, July 19th, an aerial cable under the elevated railroad at Sixth avenue and Twenty-second street was discovered to be on fire, the flames following the insulation for several feet. At times the flames were extinguished by the rain, and then broke out afresh. No damage was done to anything else.

Some time ago William T. Kitsell had made a telephone receiver and transmitter upon the Bell pattern which he placed in the Hotel Madison for his own use. The American Bell Telephone Co. brought suit against him last summer for infringement, and an injunction with accounting. Application was also made for the removal and destruction of the instruments. The case was heard in equity, Mr. Kitsell confessing the facts. Judge Wallace has granted the perpetual injunction applied for, and the demand for an accounting. He declined, however, to grant permission to remove and destroy the instruments, although he stated he had no doubt of the power of the court to enforce its decree if necessary. In English practice he says such a course is not uncommon.

Lineman George Reid, of the police department, has been presented with a silver medal and $20 cash by the New York Life Saving Benevolent Society, for his courageous action in saving John Reynolds from drowning. The lad fell overboard at the Battery on June 9th.

. . . IN working expenses I think there is little to choose between transformers and secondary batteries...... As to reliability also, I think there is little difference between the two systems. Dynamos may break down in either case, and the remedy for that is to have a spare reserve ready. Too much has been made of the reliability of the accumulator.—*W. B. Esson.*

PHILADELPHIA.

Constant Tearing up of Streets for Laying Numerous Electric Conduits.—Necessity of Single Large Conduit in Principal Streets.—The Keystone Light and Power Co. Seeking to Enforce its Right of Way against the City Government.—The Western Union Co. Closing up a Baltimore and Ohio Office.—The Suit of the City against the Baltimore and Ohio Telegraph Co.

MARKET street, east of Ninth, is constantly being torn up, and Philadelphia will never have well-paved streets so long as the present system of separate conduits, instead of one large subway, is adhered to. The Belgian block pavement on Market street was laid down in 1873 at a cost of $250,000, a special tax being levied for the purpose, and it is now fast becoming worthless. Within twelve years from the time the blocks were put down the crown of the street was broken thirteen times along a considerable portion of its length, and in the past three years no one can say how often the performance has been repeated. As a consequence the street is now in a wretched condition, and every year it becomes worse under the repeated tearings up.

The effect of the continual tearing up of the street is seen in its appearance and condition now while the Edison company is at work putting down its pipes. The pavement is uneven, rough to drive over, and after each break the crown of the street is worse than before.

It is clear that the city can have no decent pavements when they are torn up every few months. With asphalt the results would be worse than with Belgian blocks. The only remedy seems to be in the construction of a subway in which the various conduits and pipes can be grouped, and which shall be big enough for future extensions.

There are ten underground pipes and conduits in Market street; which is 62 feet wide, in addition to a large main sewer.

The pipes and conduits are:—1, 10-inch gas pipe; 2, 6-inch water pipe; 3, American Telephone and Telegraph Company's conduit, 15x13 inches; 4, 20-inch water main; 5, National Electric underground conduit, 2 feet in diameter—tubes laid in concrete, 6, Traction company conduit; 7, Traction company conduit; 8, sewer, 4 feet inner diameter; 9, Edison company's pipes, 18 inches square; 10, 6-inch water-pipe; 11, 4-inch gas-pipe.

The depth below the surface of these underground works varies considerably. The bottom of the sewer is nine feet down. The gas and water pipes are from three to four feet and six inches below the surface. The depth of the American Telephone and Telegraph, the National Electric and the Edison companies' pipes is only two feet, and of the Traction company's conduit three feet and six inches. The water main is four feet and a half down. It will be noticed that all these pipes and conduits pretty well fill the street, but the prospects are that there will be additions to them soon. The Keystone Light and Power Co. wants to put down its wires, and so do the Western Union and Bell Telephone companies. Then there is the project, still in air, of the Market Street Underground Railroad Co., which would occupy 26 feet in the centre of the street, and in the remote future it is possible that the city may want to put down conduits for its electrical system. Director Wagner wants to substitute larger gas mains for those now used; and new schemes to make use of pneumatic tubes are constantly coming up.

The Keystone Light and Power Co. filed a bill in equity recently against the City of Philadelphia in Common Pleas Court No. 1. The bill asks for an injunction against mayor Fitler and the officers of the city to restrain them from interfering with the contemplated laying of electric wire conduits on Sansom street, west of Ninth. The bill avers that by virtue of the act of Assembly of April 29, 1874, they have a right to lay the conduits after obtaining the approval of the board of highway supervisors.

On August 5, 1886, the bill claims, an ordinance was approved by councils granting the company privileges to run on certain streets, including Sansom, from Sixth to the Schuylkill. On April 21, 1887, the board of highway supervisors, through secretary Coppuck, sent in a communication to councils, saying they had examined the application of the Keystone company and had amended the route, and requesting councils to refer it to the electrical committee. Among other amendments suggested was to lay the conduits on the north side of Sansom street, from Ninth to Twenty-fourth. Councils referred the amended bill to the electrical committee, which on June 2, 1887, returned it with a favorable recommendation.

On June 16, 1887, the bill was taken up in its order, when, upon motion of select councilman Graham, chairman of the electrical committee, it was again referred to the committee, where it was permitted to die. On the first Monday of April of this year councils' term expired without further action in the matter.

Last month the company notified director Wagner that they intended laying their conduits on Sansom street, under the act of 1874, and made formal application for a permit. Director Wagner answered that as councils had failed to pass the ordinance he could not grant the permit. A letter was then sent to mayor Fitler, notifying him of the company's intention to lay their conduits without councils' permission, and stating that by their

"letters patent" they had a right to lay them after obtaining the approval of the board of highway supervisors.

The mayor last Friday answered through his secretary that the permit would not be granted, and that should an attempt be made to tear up the streets the work would be promptly stopped. It is for this reason the injunction is asked, the bill stating that the officers of the company fear interference in the exercise of their franchise by the police of Philadelphia.

The action of the Western Union Telegraph Co. in removing the wires and instruments from the office of the Baltimore and Ohio Railroad and Telegraph Co.'s office at Ninth and Chestnut streets is a reminder that Philadelphia is now almost entirely dependent for telegraphic service upon Jay Gould's great monopoly. Other offices of the Baltimore and Ohio company have been gradually closed, and practically all the business of the city is now done over Western Union wires. The only comfort to be extracted from the situation is that these actions of the Western Union all go to add testimony in favor of the city in its suit against the Baltimore and Ohio Telegraph Co.

It will be remembered that when the announcement of the absorption of its rival by the Western Union was made last December, a resolution, offered by John Fow, was immediately passed by city councils instructing the city solicitor to take steps to forfeit the bond of $50,000 filed by the Baltimore and Ohio Telegraph Co., because of its violation of the ordinance of March 21, 1883, under which it was granted permission to enter the city. The ordinance, which was very explicit, said:—

"The said Baltimore and Ohio Telegraph Co. shall give a good and sufficient bond in the sum of $50,000, to be approved by the city solicitor, with the condition that it will not consolidate with any other telegraph company owning a competing line, or acquire by purchase or otherwise any such competing line of telegraph in the State of Pennsylvania or any other state. Provided, that in case of such consolidation, merger or sale of the privileges herein granted to said company, the poles and wires and fixtures erected shall become the property of the City of Philadelphia and the said bond shall be forfeited."

The statement of the city's case, as prepared by assistant city solicitor Walton, who was given charge of the matter, is very simple. It says:—

The plaintiff claims that the defendants have violated the conditions of the said bond in this that the Baltimore and Ohio Telegraph Co. has consolidated with another telegraph company or companies owning a competing line, and has acquired by purchase or otherwise, such competing line of telegraph in the State of Pennsylvania or other state, whereby the amount of said bond has, according to the terms and conditions thereof, become due and payable.

This is followed by an affidavit by mayor Fitler, in which he says that the statement is true to the best of his knowledge, information and belief, by a copy of the telegraph company's bond, which is signed by Robert Garrett, first vice-president of the Baltimore and Ohio Railroad Co., and by the resolution passed by city councils in December.

The affidavit of defense sworn to by President David H. Bates, of the Baltimore and Ohio Telegraph Co., in New York, on February 6, is even more simple than the city's statement. It consists of the declaration that the company "has not consolidated with any other telegraph company owning a competing line, or acquired, by purchase or otherwise, any such competing line of telegraph in the State of Pennsylvania or any other state, and further saith not."

The issue is thus plainly made between the city and the company, and the necessity of furnishing proof to show consolidation of the two companies is thrown upon the city. The case has not yet been given a place upon the court list, but is expected to come up for trial in the fall. Evidence will then be offered to show that there has been such a consolidation as was provided for in the ordinance of 1883, and it is possible that some of the inside history of the deal may be brought out. Notwithstanding the affidavit of president Bates, the *prima facie* evidence all goes to show that there has been a consolidation, merger or sale, the forfeit for which is $50,000.

PHILADELPHIA, July 17, 1888.

.... I REMEMBER hearing Dr. Werner Siemens say with his own lips that it was hopeless to expect to make a dynamo with a higher efficiency than 50 per cent. He lived to see himself mistaken.—*Marmaduke M. M. Slattery.*

.... "IF I were asked for my opinion, I should strongly recommend that the adoption of the electric light in theatres should be made compulsory by act of parliament. It always seems ridiculous to me that while the outcry of exits is chronic, no one thinks of striking at the root of the evil, which is the use of gas behind the stage, where all the materials are of the most inflammable nature. Very little danger can come of using gas in the auditorium, whereas, on the stage, it is a never-ending source of danger."—*W. S. Gilbert.*

BOSTON.

Visit of General Greeley, Chief-Signal Officer in Boston; his Views of the Service.—A Reported Consolidation of Graphophone and Phonograph Interests.—An Extra Dividend by the American Bell Telephone Co.—Output of Telephones.—The Boston Common Council wants to Regulate Telephone Charges.—Electric Light at Quincy.—Electric Light wanted at Sullivan Harbor, Me.—Photographs of Lightning Flashes.—The New England Electric Exchange.—The Police-Signal System in Boston.

THE Boston signal station was inspected by General A. W. Greeley the first of the month. He is east to witness the laying of the new Vineyard Sound cable. He expressed himself satisfied with the workings of the Boston station. The late night maps, to be distributed among all the towns and cities in New England that can be reached before 11 o'clock on the following morning, are now issued. The signal service in general, General Greeley said, was improving in efficiency, but he felt it was time the department was reorganized. There are a good many incompetent men on the stations and all of the men ought to be examined. In order to get the service under the control of a bureau of agriculture, it was intended to make room for favorites and catch the farmers. It got through Congress this year by the member, who introduced it, declaring on the floor of the House that it was General Greeley's bill, which, of course, it was not. It failed in the Senate, and now the recommendation of the chief-signal officer that all the clerks in Washington should be put on the civil list, has been embodied in a bill which is likely to pass.

It is reported here that a consolidation has been effected between the Bell Graphophone Co. and the Edison Phonograph Co. Certain parties are endeavoring to form a local company to exploit the matter here.

The American Bell Telephone Co. have delighted their stockholders, by declaring an extra dividend of $6 per share for the current quarter. Subscriptions for the bonds of the American Telephone and Telegraph Co. come to hand quite favorably, it is understood; there is nothing to hinder the parent company from taking a considerable block themselves if they so choose.

The statement of the output of telephones by the American Bell company of the month ended June 20, and the first six months of the current fiscal year, is as follows:—

May	1888.	1887.	Increase.
Gross output	6,636	6,971	*335
Instruments returned	1,921	1,598	323
Net output	4,715	5,373	*658
Dec. 21 to June 20—			
Gross output	29,261	28,663	898
Instruments returned	10,876	11,114	*238
Ne. output	18,685	17,549	1,136

*Decrease.

At a meeting of the Boston common council, on the 14th inst., an order was offered, providing for the appointment of a committee to consist of five on the part of the council, with such of the board of aldermen as may join, to investigate the subject of telephone charges. The chair appointed Messrs. Hoar, Brooks, McLaughlin, Chamberlain and Dolan.

From information furnished by a prominent city official, it appears there has been considerable discussion at the City Hall relative to telephone charges to the city. The gentlemen referred to remarked that the telephone company had asked for and received many privileges such as conduit and overhead rights of way, etc., for which they had paid nothing, and as it was generally understood that other city governments received large concessions and rebates from the local telephone companies, the city of Boston officials thought that their telephone rates should also be modified.

The Electric Light and Power Co., of Quincy, have had their annual meeting and elected the following named officers: Directors, John Q. Adams, W. G. A. A. Pattee, John R. Graham, John Cashman, James H. Stetson, William B. White, W. A. Stiles; clerk, Walter M. Packard; treasurer, Horace F. Spear. The company will probably begin to light the streets of the town in a week.

The Sullivan Harbor Land Co., located on the main land of Maine, in the rear of Mt. Desert, is advertising for proposals for an electric light system for its property. Both arc and incandescent lamps will be required, and it is proposed to utilize the tidal currents, which run for four hours either way on each tide through a narrow gorge between Fall's Point, Sullivan and Hancock Neck, within 1,500 feet of the village street. Its tide waters fill an immense arm of the sea, which runs up for three or four miles behind the village, and thousands of horse-power go to waste, which it is now proposed to use, and by means of dynamos, run by water wheels and auxiliary storage batteries, light not only Sullivan Harbor, but Hancock Point, Mt. Desert Ferry and Sorrento at one-third the cost of coal.

Several very fine photographs of the lightning on its way to earth were made during the recent storms in this vicinity, and are on sale at several places. In no instance is the jagged, saw-tooth appearance shown, but the peculiar rounded serpentine wriggle is shown in all of them.

The quarterly meeting of the New England Electric Exchange was held on the afternoon of the 9th inst., at the rooms of the Boston Electric Club on Boylston street. President P. H. Alexander spoke of the interest in the exchange and the value of its work, and expressed surprise that only 25 men have applied for licenses, whereas, under the decision of the insurance companies, 600 men must obtain licenses before Oct. 1, if they desire to continue their work. Some changes were made in the plan for issuing licenses. George F. Curtiss of the Thomson-Houston Electric Co. read a paper upon "Lightning Arresters."

Orders were read at roll-call at the several police stations on the evening of the 13th inst., announcing the organization of the police-signal system. The patrol wagons and signals have been in use for some time, but the service of the men is now systematized The order provides for a director of signal service, who has charge of the apparatus of the signals and the patrol wagons. His office is at police headquarters. The patrol wagons are provided with two drivers, one for day and one for night work. With them two patrolmen are to be on duty at all times, to go with the wagon, and be under command of the driver. The wagons are to be run to fires in their districts. Lieutenant H. O. Goodwin, of Division 6, has been assigned to special duty as director of signal service.

Sergeant Charles W. Bower, who has been in charge of the street railway squad, is promoted to the rank of inspector, and appointed inspector of street railway service.

BOSTON, July 16th, 1888.

CHICAGO.

Plans for a Great Underground Electric Railway System.—The Chicago Electric Club; Annual Election; Its Year's Work; Prospects for Next Year.—The City's Arc-Light Plant.—A Batch of Electric Light Franchises Granted by City Council.—The Council and the Chicago Telephone Co.—Death of Alderman Thos. C. Clarke.—A New Focusing Arc Lamp by Mr. E. O. Warner.—Pacific Ocean Cable Scheme.—Suit Against the Chicago Arc Light and Power Co.—The Electric Light Station at Port Huron Burned. —Mr. D. H. Lauderback Resigns the Managership of the Chicago Edison Co.—The Van Depoele Company.—The Chicago Insulating and Construction Co.—Other New Incorporations.

THE Chicago Underground Railway Co. has been incorporated. The object of the corporation, as the name indicates, is to build under the streets of Chicago a railway connecting all the suburbs with the centre of the city. The projectors say that the road is to be modeled after the Metropolitan railway system of London, but that the disadvantages of the latter line—darkness and smoke—will be overcome by the use of electric motors and electric lights. According to the plan, the tunnels will radiate from a central point and will be located about 100 feet below the surface. If a pocket of quicksand be met, riveted iron tubes will be forced through the bed. The cost is estimated at $1,000,000 per mile. The capital of the organization is $27,000,000. A great many arguments in favor of this system can be advanced, but the great question—whether the road can pay interest on the investment—has not yet been answered to the satisfaction of capitalists. Those interested in the scheme seem confident that the project will eventually be successful. The view which the public takes of the project is well given in the following extract from a Chicago daily paper :—

> The proposition to build an underground railroad system for this city, offers a happy solution to a long-vexed problem. The only reasonable hindrance to giving it an unqualified indorsement lies in the question, "Can it be made to pay?" There need be no doubt in regard to the possibility of doing the work, and in such a manner as shall render the route an acceptable one to many thousands of people who wish to travel each day between the central portions of the city and its suburbs. The introduction of electricity for power and illumination, with the use of elevators for transferring passengers to and from the street level, can be made to obviate all the objections that have been raised against the underground railway in London. Such a line would relieve the pressure of travel on present thoroughfares instead of forming the additional incumbrance threatened by either the street or alley line of elevated road, and if sunk so far below the surface as is proposed neither noise nor shaking would trouble the residents in the city overhead. The cost of construction is a matter for the engineers to decide upon, and then it must be left to the capitalists to say whether or not the scheme is pecuniarily practicable. For the great public, which wants cheap and rapid transit at a low cost and with the minimum of annoyance, there is but one side of the argument that has any weight. That side is the affirmative one.

At the annual meeting of the Chicago Electric Club, the following officers were elected: President, S. A. Barton; vice-presidents, 1st, C. A. Brown; 2d, J. P. Barrett; 3d, B. E. Sunny; 4th, H. Ward Leonard; secretary, W. A. Kreidler; treasurer, F. S. Terry; managers, C. D. Shain, F. E. Degenhardt, E. B. Chandler, J. H. Reid, Theo. P. Bailey, A. K. Stiles, C. C. Warren, W. J. Buckley, M. A. Knapp, Geo. L. Beetle; membership committee, C. C. Haskins, J. W. Clark, Geo. Cutter, W. H. McKinlock, F. W. Horne. Treasurer F. S. Terry in his annual report mentioned the fact that $1,000 had been expended for fitting up the club rooms. He urged the necessity of increasing the membership that the club might have sufficient income to defray all expenses. The report of the board of managers after felicitating the members on the work of the year and the bright prospects of the club, continued as follows:—

> While the finances of the club are not just now in as satisfactory a condition as could be desired, they are not at all desperate, considering the fact that another quarter's dues will be payable at an increased rate in about two weeks. It has been thought advisable to give members who are interested in the club and receive its benefits an opportunity to subscribe for the further furnishing of our rooms. It seems reasonable to expect that $1,000 can be raised in this way, which will leave the club free from indebtedness, and with property to the value of $2,000 on hand. The value of the papers read before the club and of the discussions following them, is sufficient to suggest the expediency of having them printed in pamphlet form, as is done in the Institute of Electrical Engineers. The social, scientific, and business advantages of the club are such as to insure its continued growth and prosperity, and it is predicted that it will soon be necessary for the club to have a house of its own.

S. A. Barton, of the Thomson-Houston company, the new presiding officer of the club, proposes to institute a vigorous policy, which will establish the association on a much more substantial basis and make it an effective and active organization. The club has already accomplished much in the way of promoting a more social feeling among the members of the electrical fraternity, and the association has reason to consider with satisfaction the quality of the papers which have been presented from time to time. A club house is talked of, but as yet nothing definite can be reported on this question.

Preparations are making for lighting the city from its new electric light plant. The appropriation for the plant was $35,000, and the capacity will be 450 2,000 c. p. lamps. In all the streets crossing the river several lights will be located within two or three blocks of the stream. The east side district, first to be lighted, will be between Michigan avenue, Madison street and the river; the west side between Van Buren, Halsted and Washington streets and the river. It is expected that Madison street will be lighted as far west as Western avenue. This will be the beginning of the general system of city illumination.

The first meeting in July was electric light night in the Chicago city council. The ordinance giving the Sun Electric Light Co. the privilege of laying wires to furnish "light, heat, power and signals" between Adams and 22d streets and the lake and the Chicago river was passed. The matter had been slumbering in council committees for months. It was voted that the company pay into the city treasury five per cent. of its gross earnings as consideration for the franchise. The original ordinance provided for the payment of 2½ per cent. A similar franchise was granted to the north side company to operate lights in the north-west part of the city. The same consideration for the franchise was exacted. The Consumers' Electric Light Co. was granted the privilege of operating lights south of Harrison street between Blue Island avenue and Halsted street on the same terms. On the same conditions the Co-operative Electric Co. was granted the right to operate lights on the entire north side, south of Fullerton avenue. Some opposition was made to the passage of the ordinances on the ground that it was poor policy if the city contemplated the installation of an extensive electric light plant to give to rival companies a strong foothold in the heart of the city.

The officers of the Chicago Telephone Co. looked forward to the city council meeting of July 9 with decidedly unpleasant anticipations. An ordinance had been introduced reducing the rates of telephones in the city to $75 per year. The resolution was modeled on the St. Louis resolution which brought on the fight in that city. The aldermen as a body favor the telephone company very little, but fortunately this effort to strike a blow at the company was unsuccessful. Superintendent Phillips, when asked his opinion of the proposed ordinance said: "I am not prepared to say what the company will do if the council passes the ordinance. We will not cross the bridge till we get to the river. I hope and think that before final action is taken a conference will be held and a full statement of the company's side of the case will be considered. It has been my honest ambition to give Chicago the best telephone service in the world, and this statement, I think, is proved by the money which the company is expending. A switch-board costing $60,000 has recently been put in, and other expensive improvements are being made." The ordinance was referred to the committee on licenses, and it will remain there for some time at least.

Alderman Thomas C. Clarke, chairman of the committee on fire and water, of the Chicago city council, died suddenly July 6. He was mainly instrumental in securing for the city the electric light plant which it now possesses. Last year he carried out the idea of lighting the bridges and the river by electricity. He was the author of the bridge telephone system.

Mr. E. P. Warner, of the Western Electric Co., has invented a new focusing arc lamp which is designed particularly for the use of river steamers. It can be used with different kinds of reflectors as occasion requires.

Matthew Gray, well known as an engineer, while making a visit in Chicago recently made the statement that the work of constructing a cable across the Pacific would soon be begun. He was sent as a representative of the Silvertown Submarine Cable Co. to Vancouver and to Australia, to investigate the feasibility of laying the line, and he made a highly favorable report. It is said the cost will be between $15,000,000 and $20,000,000.

Joseph Reinstein has commenced suit against the Chicago Arc Light and Power Co. to obtain $5,000 damages. He was injured in the explosion which occurred about May 1, in the Bell clothing store. The explosion was caused by the ignition of gas leaking from a main which was broken by the employés of the defendant company in forcing a tube for wires under the sidewalk.

A despatch received in Chicago July 11, stated that the Excelsior Electric Light Co.'s building at Port Huron., Mich., was burned. The structure contained eight dynamos, two engines and a considerable quantity of supplies. The electric railway which was supplied with current by the company was disabled. The loss was $10,000 and was covered by insurance. The company immediately commenced to consider plans for rebuilding.

D. H. Lauderbach has resigned as general manager of the Chicago Edison Electric Light Co.

The Van Depoele company will install a 100 h. p. electric plant at Rockford, Ill., for the distribution of electricity for power. The same company has installed an arc light plant on the John A. Dix, an excursion steamer running from Chicago.

The Chicago Insulating and Construction Co. with $250,000 capital stock, has been organized. The incorporators are E. B. Palmer, E. A. Mulford and L. M. Hunter. The company will manufacture insulating materials and supplies.

The 31st Street Electric Light Co. of Chicago, has been incorporated. The capital stock is $50,000. The charter gives the company the right to sell current for motor power as well as light. Those interested in the company are J. J. Shimers, J. J. McEvoy, S. F. King and Owen O'Neil.

The Gaston Electric Headlight Co., of Chicago, has been organized to manufacture electric headlights and electric supplies. The projectors are J. E. Gaston, J. R. De Mier, D. P. Barker and R. J. Harmer.

The Chicago Electric Motor Co. has been formed. The capital stock is $30,000. The corporation will manufacture electric appliances. The projectors are R. H. Garrigue, J. C. Scroggs, J. H. Claswell and H. S. Tiffany.

The American Telegraph and Telephone Co. has been incorporated, with headquarters at Chicago. Those interested in the company are Russell C. Whitmore, William Speirs and Albert R. Rawson.

The Elmer A. Sperry Co., of Chicago, has been incorporated. The company will install electric light apparatus. Those interested in the company are Elmer A. Sperry, George Lawrence and J. G. Marsh.

The Fowler Insulating Co., of Chicago, has been incorporated with $150,000 capital stock. The object of the company is to make insulating and fire-proof materials. The incorporators are Preston B. Rose, Thomas Connelly and Frank A. Fowler.

The Englewood Electric Light Co., of Englewood, a suburb of Chicago, has been incorporated with a capital stock of $50,000. The incorporators are Joseph Badenoch, Jr., John I. Badenoch and Charles T. Page.

The Delevan Electric Light Co., of Delevan, Ill., has been incorporated. The incorporators are J. M. Allen, A. I. Maclay and F. E. Allen.

A certificate of incorporation has been issued to the Brush light company, of Charleston, Ill. The capital stock is $15,000. The object of the incorporation is to deal in motor and electric apparatus, and to operate motor and electric plants. Those interested in the company are E. L. Link, E. Cadle and C. E. Winter.

The contract for lighting the Auditorium building has been awarded to Leonard & Izard. The cost of the plant will be about $50,000. There will be installed 8,600 lights.

CHICAGO, August 22, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall street, New York city.*

WELDING RAILS BY ELECTRICITY.

[96.]—*Dear Sir:*—In the July number of your magazine, Mr. Elias. E. Ries publishes a long epistle in which he endeavors to expose my ignorance of electric welding and the folly of what he is pleased to call *my criticism* of his " method of electrically welding and tempering " rails, which he states appeared in your June number. I shall not crowd your columns with a reply in detail to Mr. Ries, more especially as those who are familiar with the subject will, I think, consider most of his reasoning answered as soon as stated; but for the sake of those who know but little of electric welding, I would like to exhibit a single specimen of what Mr. Ries would doubtless call my *ignorance* and his *knowledge* of this subject. Before doing so, however, permit me a word of digression. As to Mr. Ries' explanation of my motive in writing my previous letter, and other such personalities which fill about one-third of his letter, I will say nothing. Courtesy would also, it seems to me, enforce silence in relation to the pending interference between Mr. Ries and Professor Thomson; and I must, therefore, positively decline to say anything in regard to this matter. I have no doubt that Professor Thomson will be well able to take care of all matters relating thereto.

It may be well here to make a correction, and state plainly the issue between us. My letter was *not* a criticism of what Mr. Ries calls his " method of electrically welding and tempering " rails; it was not a criticism of any one's method. The general statement was made, and it was this which prompted my letter, that it was proposed to weld tempered steel rails into continuous lines of track with subsequently retempered joints. It was my opinion that important details of the problem had not been considered in the proposition. My letter, therefore, was simply a brief statement of some of the difficulties which would inevitably be encountered in carrying such a project into effect. It is Mr. Ries who drags his " method " into the discussion, and, therefore, I can see no reason why I should not briefly respond to Mr. Ries. The question then is: Does Mr. Ries' " method " meet the difficulties referred to in my letter? To determine this I will examine one of Mr. Ries' statements, and to insure fairness, will take the first he makes.

Referring to my statement that there would be on each side of the joint an annealed portion which could not be tempered without heating the whole track, Mr. Ries says that this may be true with regard to the peculiar tempering process practiced by myself, but adds that if " Mr. Stuart will glance at a copy of the patent above referred to, describing this method of welding and laying railway tracks, he will find, among other things, the two following claims, which not only describe the method by which a uniform, temper *is* produced, but which cover broadly the art of electric welding in which current strength is gradually increased to prevent burning the metal and permanently destroying its tempering qualities at the joint," etc. The claims are then given in full.

I was acquainted with Mr. Ries' patent when I wrote the letter he replies to, but I was then, and am still, unable to find any method of restoring uniform temper to an annealed portion of a steel structure, described either in the claims quoted or in the specification referred to; I have no hesitancy in saying that Mr. Ries has neither described nor practiced such a method. Nor is this all, for if it were necessary, in order to make a method practicable, merely to describe it, perpetual motion would have been a grand success, as the records of the patent office amply demonstrate. Does Mr. Ries suppose that even if a method were described in his claims or specification, that it would of necessity be practicable? But aside from all this, I state positively that a greater piece of electrical nonsense has never been written than this statement of Mr. Ries; and its absurdity lies in this, that the gradual increase of current strength, while it does not destroy, has nothing to do with preserving the tempering qualities of steel. I have frequently welded steel without injuring its tempering qualities, by abutting the pieces, passing through the joint a definite strength of current and gradually *reducing* the flow of this current as the heat went on. It makes no difference how the current is applied, whether gradually increasing, alternately increasing and decreasing, gradually decreasing, etc. Provided the current is of sufficient quantity to effect the weld, and not excessive, *the heating effect will and must be gradual*; and nothing but *heat plus gas* has any effect upon the tempering qualities of steel. Does not Mr. Ries know, that if an amount of current, sufficient to effect the weld is passed through the abutting ends of two conductors, the ends will begin to heat, and a subsequent gradual welding can be effected with even *less* current than was used at the start? The heating effect is equal to $C^2 R$, and it is evident that if R be increased, C^2 can be decreased proportionately. Is it possible that Mr. Ries does not know that a gradual heating effect must be produced no matter how the current is applied, providing said current is of sufficient strength? Or does he suppose that by gradually increasing the current he has conferred upon it a virtue so peculiar and so subtle as to keep intact the tempering properties of the metal in spite of the action of heat and gas?

Looked at from a different standpoint, it is apparent that Mr. Ries has forgotten the conditions under which steel loses its tempering qualities. He forgets that in dozens of foundries in this country steel is melted and poured into moulds with no " gradual increase of the current to prevent burning!" The real cause of the so-called burning of steel is to be looked for in the combination, due to heat, of the metal with extraneous gases, which produces " grit," destroys homogeneity, and prevents an intimate coherence of the particles. In view of this fact, is not Mr. Ries' position manifestly absurd?

I think it is evident that Mr. Ries' scientific opinions are not always to be accepted as truth. In fact, I can see nothing in his letter which could tend to alter an opinion in respect to the practicability of the scheme under consideration. One thing is certain, viz; that the best way to solve the problem is to construct a railway with continuous tempered steel tracks, and endeavor to operate it; and I am glad that Mr. Ries is now engaged in this work, as he seems to intimate. But I venture to predict that the great railroads of the country will not soon adopt what Mr. Ries so glibly calls his "method of electrically welding and tempering metals as applied to the construction of railway lines."

Yours truly,

OTIS K. STUART.

LYNN, Mass., July 17, 1888.

LITERATURE.

REVIEWS.

Die Construction der Magnet-Electrischen und Dynamo-Electrischen Maschinen. Von GUSTAV GLASER-DE CEW. Fünfte, umgearbeitete und vermehrte Auflage von Dr. F. Auerbach. Wien, Pest, Leipzig. A. Hartleben's Verlag.

THIS is a small volume of 253 pages, containing in convenient form information that one might have to go far to find elsewhere. Being a small book it does not pretend to contain a complete list of all the dynamos constructed to date (1887), nor full descriptions of all those treated. The author contents himself with detailed accounts of a few machines, which serve as types, and brief mention of several others developed from them, in which the points of difference are indicated. The present (fifth) edition is an improvement in many ways over the first. The most noteworthy machines introduced in the six years succeeding the first edition have been described in the fifth, and the theoretical and mathematical discussion of the details of construction have been relegated to another volume. This is good on the score both of brevity and of unity of plan. The book is not intended to give dynamo builders instruction in the art, but rather to present for general information the development of the dynamo from its earliest form to the diverse styles in use to-day. It supplies a felt want and cannot fail to be useful to those who desire information regarding the machines in use in Europe and this country. The reader feels a disappointment at times that the information is not complete. One would like to know, for instance, the work that can be expected from each machine. One misses, too, in many cases mention of the nationality of the inventor and place of construction. These facts, to be sure, are given in regard to the most important machines; but it would add to one's satisfaction to learn the same of all without recourse to other sources. Such statistics could have been incorporated without making the book exceed its proper limits.

The subject-matter is included in six chapters and an appendix, and a good index makes the work of reference easy. The first chapter treats of the principles and historical development. The second and third constitute a more or less complete description of some 75 different machines. The fourth takes up some details of construction and instruments for electrical measurements. The fifth and sixth are concerned with the uses to which dynamos have been put. The appendix contains the formulas of Du Moncel for the construction of electro-magnets. Just what appropriateness this appendix has in a book that pretends to exclude theoretical and mathematical discussions, it is hard to see. The space it occupies could have been better filled by information of the kind that fills the fifth chapter.

The first chapter is the least open to criticism. The account of the historical development and the discussion of principles is concise, logical and clear, and serves as a good introduction to the descriptions which follow. In the second and third chapters, besides the omissions already noted, one feels constrained to criticise the classification. The first division made is on the basis of the kind of current generated, and the classification is made of (1) alternating and (2) continuous current machines. The author says (p. 36), "There is needed for a rational classification a grouping of these [machines] according to the nature of the currents generated in them." And again—"Of course, by the use of a commutator a continuous current can be derived from any alternating current machine." On this basis, he proceeds to describe several alternating current machines, including some in which, by means of a commutator, the machines are not only used for plating but for self-excitation. One machine, Möhring and Baur (pp. 47, 148), he puts under both classes. In arranging the sub-classes of the continuous current machines, the division after the mode of excitation is discarded and the machines grouped as, 1, ring machines; 2, drum machines; and 3, machines of various systems. These classifications have obvious advantages; but in view of the fact that they are not mutually exclusive, and are sometimes misleading in name, it would seem that a classification which regarded merely the maker, would be complete and satisfactory. The nature of the current, the mode of excitation, the shape of the armature, etc., could in that case be perfectly expressed in tabular form. Considerable attention is paid to the various forms of the Gramme machine, and those constructed by Siemens & Halske; American inventors are given due credit; but one is surprised to find no mention of the Westinghouse system. Doubtless the author was unaware of its success, for he merely hints that there is a large field open for the alternating current machine by means of the "so-called transformers."

The fourth chapter in which the author states with a few examples, the principles on which the field magnets, armature, commutator, etc., should be constructed, and describes the instruments used for electrical measurements, contains nothing new. The plan adopted of indicating principles rather than multiplying examples is thoroughly adapted to the scope of the book. It is to be regretted that data of tests, such as are given in the fifth chapter, are not more numerous. Those tabulated are very interesting; but they would have commended themselves more to the American reader, had they been represented graphically. On the whole, the book is a contribution to electro-technical literature, and, with its numerous engravings, may prove suggestive as well as a convenient source of information to the electrician.

RECENT PUBLICATIONS.

A Course of Lectures on Electricity, delivered before the Society of Arts. By George Forbes, M. A., F. R. S. (L. & E.). London and New York: *Longmans, Green & Co.* Crown 8vo., cloth, 163 pp. Illustrated. Price $1.50.

An Index to Engineering Periodicals, 1883 to 1887, inclusive, comprising Engineering; Railroads; Science; Manufactures and Trade. By Francis E. Galloupe, M. E., Mass. Inst. Technology, S. B., Member Am. Soc. Mech. Eng. Boston and New York, 1888. 12mo., 294 pp. Price, $2.00.

American Electrical Directory for 1887-8. Published by the *Star Iron Tower Co.*, Fort Wayne, Ind. 8vo., 749 pp. Price, $2,00.

All Matter Tends to Rotation, or the Ultimate Source of Motion, Demonstrates from Scientific Data, with a Mechanical Explanation of every Form of Energy as a necessary Resultant of the Tendency of Matter to Ceaseless Rotation. By Leonidas LeCenci Hamilton, M. A. Vol. i., Origin of Energy, Electrostatics and Magnetism. Boston: *Cupples & Hurd*, 1888. 8vo., cloth, 340 pp. Price, $3.00.

Electrical Instrument Making for Amateurs, a Practical Hand-Book. By S. R. Bottone. Second Edition, enlarged by a Chapter on the Telephone, etc. London: *Whittaker & Co.* New York: *D. Van Nostrand*, 1888. Small crown 8vo., cloth, 183 pp. 60 illustrations.

Esperienze di Confronto fra Varii Tipi di Accumulatori Elettrici eseguite dal Prof. Tito Martini, Socio. Corr. del R. Instituto Veneto di Scienze, Lettere ed Artis. Venezia: *G. Antonelli*, 1888. 10 pp.

Management of Accumulators and Private Electric Light Installations, a Practical Hand-book. By Sir. David Salomons, Bart., M. A., A. I. C. E. Fourth Edition, Revised and Enlarged. London: *Whittaker & Co.* New York: *D. Van Nostrand.* Small Crown, 8vo., 176 pp., 35 illustrations.

Proceedings of the National Electric Light Association at the Second Semi-Annual Convention held at Detroit, Mich., August 31-September 2, 1886, and at the Third Annual Convention held at Philadelphia, Pa., February 15-17, 1887. Boston: Press of *Modern Light and Heat*, 1888. 8vo., paper, 546 pp.

CATALOGUES AND PAMPHLETS RECEIVED.

The Thomson Electric Welding Co., Mason Building, Boston, issue a very tasteful pamphlet circular announcing their readiness to supply machinery and apparatus for electric welding, under Professor Thomson's patents. The circular briefly but clearly describes the principle and methods involved in electric welding, and is illustrated by several extremely fine engravings of the machines offered. Under the headings "Practical Value of the Welding Process" and "Applications to General Metal Working, Shaping, Forging, Tempering, Etc.," much information useful to metal workers is given.

Messrs. Eugene Munsell & Co., 218 Water Street, New York, send us a small thermometer neatly mounted on a sheet of mica of very superior quality. We can hardly call it a catalogue or a pamphlet, but may perhaps include it among circulars, as it bears the advertisement of the firm printed in gilt letters upon the mica sheet.

The Westinghouse Machine Co.'s circular, describing and illustrating their compound engine can not fail to interest general readers as well as persons directly concerned with questions of economic steam power. The gist of the whole is succinctly given in tables of some tests of condensing and non-condensing engines printed on the cover.

ELECTRICAL NEWS AND NOTES.

THE ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.

SEVENTH ANNUAL MEETING.

THE seventh annual meeting of the Association of Railway Telegraph Superintendents was held at the Murray Hill Hotel, New York city, on Wednesday, July 11th. The meeting was called to order at 10 o'clock A. M., by President G. L. Lang, of Boston. The president, upon opening the meeting, feelingly alluded to the deaths of three members of the association during the past year, namely, Mr. Wynkopp, of the Pennsylvania company; Mr. Bartlett, of the Providence and Worcester R.R., and Mr. King, of the Quincy, Missouri and Pacific R.R.

Mr. Lang briefly outlined the business that would be brought to the attention of the association; stating that measures should be taken to bring about more intimate relations with the General Time Convention of the United States, and that some action should be taken to secure uniform electrical time signals from the various

observatories, thereby insuring accurate standard time to all the railroads throughout the country. With that end in view, Commander Brown, in charge of the Naval Observatory at Washington, had been detailed by the Honorable Secretary of the Navy to address the association on the system of transmitting time signals from the observatory.

The following members were present:—G. C. Kinsman, Wabash railway, Decatur, Ill.; P. W. Drew (secretary), C. & E., Ill., Chicago; C. S. Jones, Ill. Central, Chicago; G. E. Simpson, C. M. & St. P., Milwaukee; S. S. Bogart, West Shore, Weehawken, N. J.; J. B. Shaw, N. Y., P. & O., Jamestown, N. Y.; C. W. Hammond, Mo. Pac., St Louis, Mo.; T. J. Higgins, C. C. C. & I., Cleveland, O.; C. A. Darlton, R. & D., Washington, D. C.; N. E. Smith, N. Y. & N. H., New Haven, Ct.; E. A. Smith, Fitchburg railway, Boston; J. D. Gibbs, Mo. Pac., Sedalia, Mo.; E. M. Herr, C. B. & Q., Chicago; A. R. Swift, C. R. I. & P., Chicago; H. C. Sprague, K. C. Ft. S. & C., Kansas City, Mo.; H. P. Houghton, Wabash railway, Butler, Ind.; G. T. Williams, N. Y. C. & St. L., Cleveland, O.; C. E. Topping, now superintendent U. S. Express Co., N. Y.; Robert Stewart, C. R.R. of N. J., Elizabeth, N. J.; J. J. Stenson, L. I. R.R, New York; J. W. Lattig, L. V. R.R., Bethlehem, Pa.; F. P. Cummings, N. Y., N. H. & H. R.R.; Horace Johnson, Grand Central Depot, N. Y; I. Cohen, H. & T. Central, Houston, Tex.; M. B. Leonard, N. H. & M.V., Richmond, Va.; W. J. Holmes, N. Y., L. E. & W., N. Y.; C. Selden, B. & O., Baltimore.

The following new members were elected:—A. E. Smith, New Haven; N. B. Patterson, Mattoon, Ill.; Robert Stewart, Elizabeth, N. J.; F. W. Wilson, Fort Wayne, Ind.; J. E. Duval, Ottawa, Ont.; W. B. Blanton, Dubuque, Ia.; J. A. Lockard, Atlanta, Ga.; J. G. Pinkerton, Amory, Miss.; C. H. Hopkins, Norwich, N. Y.

After the reading and acceptance of the report of the secretary and treasurer, Mr. Bogart, from the committee appointed last year to examine the various devices used for recording the signals transmitted over telegraph wires, made a verbal report. He had examined the self-starting register manufactured by different establishments, and that made by the Western Electric Co. would be included in the exhibit of that company, which, with many others, would be ready for inspection Thursday morning. It was the intention to have the register operated by an electric motor in lieu of a spring or weight.

President Lang, after announcing that the various exhibits would be ready for examination at nine o'clock the next morning, introduced to the meeting Commander A. D. Brown, of the Naval Observatory, Washington, who, he said, would explain to them some of the features in connection with the distribution of standard time.

Commander Brown, in taking the floor, said that he assumed that they would be more interested in the sending out of the time signals than in the methods pursued in obtaining the correct standard. He, therefore, confined himself to saying that they depended upon the stars for their observations rather than upon the sun, as is more generally supposed. These are made every evening at as early an hour as possible. At 11 o'clock P. M. the standard clock is compared with the sidereal clock, and the operation is repeated at 9 o'clock the following morning, the comparison being made by the chronograph. By this method the error existing at the time is ascertained. Any change in the density of the atmosphere, as shown by the barometer, has a great effect on the clock. Every day at 11.40 A. M. the officer in charge of the transmitting clock is informed of the error. The standard clock is allowed to run on from year to year without alteration. A great many people put weights on the pendulum to counteract the difference in the rate. At Washington they allow the standard clock to run on and accumulate the error. The transmitting clock is set every day at 11.40, and is kept on Washington time. This clock runs within one-half to one second. In setting it the pendulum is accelerated or retarded until it is brought into unison with the standard when they are compared by the chronograph. At 11.45 they are as near together as it is possible to get them. This process is repeated every day whether the observation is made or not. If the weather be cloudy the clock must be run on its own record. On one occasion when no observation could be taken for eight days, they found the clock about eight-tenths of a second out, while at another time there was a difference of but one-tenth. The discrepancy arose from the fact that the allowance made for the change in barometer was not so correct in one case as in the other. The time sent out is as accurate as possible. The transmitting clock is entirely automatic in its action; there is no handling of the key.

They also have a clock system for the local distribution of time, which has finally been adopted after many years of experimenting. The clocks used upon it are the ordinary eight-day clocks, which are synchronized by the transmission of an electric signal at noon each day. They have been in operation about four years. There are about 400 of them altogether, of which 200 are in the government service. During the last year there has been quite a demand for these clocks by the railroad companies. He believed that when the true merits of the system were more generally known among railroad people they would come into more general use. He considered it exceedingly important that they should have the best that could be devised.

It is best to have a standard, even if it is not a good one. The Naval Observatory has given time for many years to the Western Union company, and the Baltimore and Ohio company up to the time of its amalgamation, and is open to all who ask for it. He did not think that the importance of standard time could be overrated. It is not because they can do better than any one else, but for the reason that they have a large force to give it their entire attention. In answer to inquiry by the president, Commander Brown said, that the clocks in question could not be operated by the signals sent from all observatories. One of their clocks had been left at Altoona to be tested by the Pennsylvania railroad, but it did not give satisfaction, as the signal stroke sent from the Alleghany observatory was not suitable for it.

The president stated that all roads running out of Boston obtained their time from the Cambridge Observatory.

Commander Brown, in reply, said that every observatory has a different signal, each from the other. The Naval Observatory has had the railroad service in view for many years.

Mr. Jones, of Chicago, having stated that the Limited Time Co. obtained its signals from three observatories, viz., Washington, Madison and Evanston.

Commander Brown said it was very bad practice obtaining time from three observatories. This had been proved by experience at New York, where the local time service is in charge of Mr. Hamblet. At one time he received signals from five different observatories. He made a record every day of the error, and it was evident, from looking at it, that by taking the mean we should get into trouble.

Mr. Smith, of New Haven, stated that there was almost invariably a difference of one second between the time from Washington and Yale observatories.

Commander Brown stated that at Washington they pay more attention to accuracy and details.

At one observatory the weather may be cloudy and another clear. It is better to take the time from one observatory and stick to it.

Mr. Jones, of Chicago, said that the matter of standard time was assuming considerable importance in the west, and when a proper system was shown, it would be generally adopted. He was not aware whether it was safer to rely for accuracy on the enthusiasm of professors or the competition developed between private parties.

Mr. Herr, of Chicago, stated that he had been using about four months eight self-winding clocks located at various points, which had been synchronized by signals from Chicago; lately, however, Mr. Pond has started a time company, and is now receiving time signals from two observatories. He proposes to synchronize. His business, comprising different systems and clocks, has been doing very well. They synchronize only when the variation is less than half a minute.

Mr. Darlton said that the Gardner clocks were in use on the Richmond and Danville line over an extent of 2,500 miles. They are set at noon each day. The signals are sent over the railroad wire from Washington. The synchronizing device may be attached to any clock at a very small expense.

In reply to a question by Mr. Jones, Commander Brown said that the transmitting attachment added to a fine clock did not retard it, as the work required was so very slight. The attachment is not connected with the pendulum. It is on the seconds arbor, but not in the train. Mr. Williams, of Cleveland, thought that Professor Gardner's attachment required a very long contact on the 60th beat. The signal which they received from Washington, was a very short dot, not even a Morse *e*; it should be as long as a Morse *t*. Mr. Jones enquired if the magnetic influence which caused variation in the rate of watches would apply in any case to clocks.

Commander Brown replied that there would be nothing of the kind in the case of a clock. There was no doubt as to the variation in watches caused by magnetism, especially with watches used on a railroad. He had made a great many tests of the Giles' anti-magnetic shield, and also the Geneva non-magnetic watches. The Giles watches performed as well as a watch could, so far as their protection under ordinary circumstances was concerned. The shield was not, however, a thorough protection under all circumstances. He magnetized all of them, but had to place them close to the poles of the dynamo in order to do it. The non-magnetic watch was not affected at all. The first he tested he could stop in a magnetic field, the other sent to him he could not stop. The difference between them was explained by the fact that a steel fork was used in the mechanism of the first watch The question is not settled as to how these watches are going to wear, as they have been in use but a comparatively short time. Unless we put a shielded watch very close to a dynamo it will not be affected by the magnetic influence. There is no question but that the Geneva watch is compensated for temperature. The balance wheel is made of two different alloys of palladium sweated together.

Mr. Leonard, of Richmond, said that he made tests with the Giles shield, and had never found it subject to the influence of a Thomson-Houston machine.

Mr. Herr replied that in his test he had used the Ball dynamo,

in which the field is much more intense than in the Thomson-Houston machine.

Commander Brown explained that compensation for temperature is very difficult to obtain. He had just finished testing 40 chronometers which were compensated for a temperature of 70 degrees. The makers have told him that in respect to compensation they work in the dark. We cannot get a watch or chronometer that will run within a second at all temperatures without an auxiliary balance. Palladium has been used as a balance spring for chronometers with the idea that it would not rust; but the metal was not satisfactory as a spring. It does not act the same as steel, and its use for that purpose in chronometers has been abandoned.

The president enquired of Mr. Bogart, whether the time signals from Washington were sent direct through the New York office to New England, or whether repeaters were used.

Mr. Bogart replied that the signals passed through four repeating points in the New York office.

Mr. Jones stated that in 1869, while at Albany, he carried on experiments for a year or two in conjunction with the professor in charge of Dudley Observatory. They made up a metallic circuit of 2,000 miles, and they fixed the speed of the signals over this wire at 36,000 miles per second, $\frac{1}{100}$th of a second being consumed by the movement of each armature in the circuit. Very careful observations were made. The armature time must be taken into account, and if its movement is sluggish the time occupied is more than $\frac{1}{100}$th of a second.

There being no further discussion of the time question, Mr. Topping announced that the Hon. J. H. Starin had extended to the association an invitation to visit Glen Island. Transportation had been provided for 120 guests, and the steamer would be at the foot of East 32d street at 3.15 P. M.

The Long Island Railroad Co. had also extended an invitation to visit Manhattan Beach. Superintendent Holdridge of the Woodruff Palace Car Co. had provided coaches which would be in readiness at Hunter's Point, at 5 P. M. on Thursday.

The president announced that an invitation had been received from Mr. Henry Harley, to visit the tunnel on the West Shore road, and examine the working of the signals at that point.

Mr. Bogart stated that superintendent C. W. Bradley would furnish an engine and coaches. The signals referred to were a new departure. They count every pair of wheels that goes on a block, and report the same number as they pass off.

The thanks of the association were voted to the various parties extending the invitations, and it was decided to visit the West Shore signals on Friday. At 1 o'clock P. M. the meeting adjourned until Thursday morning at 10 o'clock.

SECOND DAY'S PROCEEDINGS, THURSDAY JULY 12, 1888.

The meeting was called to order at 10.30 A. M., by President Lang, who announced that the next business would be the report of the committee appointed last year to report upon the adoption of a substitute for the long dash now used as the character for the "cipher."

Mr. Selden reported on behalf of the committee, that they had conferred by letter. They had called upon representatives of all the telegraph companies, and presented symbols suggested by different parties. Every new character suggested, however, conflicted with something already in use. If the letters were made correctly by an operator no trouble would arise from the confliction of characters now used. A feeling existed among all people identified with telegraphy that we should not make any change in the Morse alphabet. Upon motion of Mr. Bogart, the committee was discharged.

A telegram was read from O. C. Green, N. P. R. R., calling attention to the fact that superintendents did not act promptly in reporting discharged men. A general discussion ensued in which the practice of reporting the discharge of operators through the secretary's office was commented upon by the different members present. It was maintained that this system was not a black-listing scheme, as has been generally stated, but merely a system by which the records of applicants for positions could be determined without loss of time, and voluminous correspondence. It was decided to make no change in the existing methods, but it was generally understood that the superintendents would co-operate with the secretary in distributing prompt information of this character. The following officers were elected for the ensuing year: G. C. Kinsman, Decatur, Ill., president, C. A. Darlton, Washington, D. C., vice-president; P. W. Drew, Chicago, Ill., secretary and treasurer.

Mr. J. W. Lattig, on behalf of the Lehigh Valley railroad, invited the association to make a trip to Easton over that line and inspect the working of the train telegraph in practical use. The invitation was accepted, and the members notified to take the one o'clock train from Jersey City on Friday.

In reply to an enquiry by Mr. Selden as to their experience with the train telegraph during the blizzard last March, Mr. Lattig said that it was their only reliance for telegraphic communication for three days. All the relief and supply trains were governed through the medium of the train telegraph, and its operators were on duty night and day. A serious accident occurred at this time, and there was no other means of communicating with the wreck. The wire was broken once on Monday at Boundbrook by other wires falling upon it. Their experience had been that this system works better in stormy than in dry weather. The use of it for commercial telegraphing was gradually increasing. None of the previously existing telegraph offices had been abandoned by reason of its introduction, because the growth of business on the road required constantly increasing facilities. A gravel train had been equipped with the apparatus, which was engaged in the construction of an additional track. One hundred men were employed on this train, and during the first week one hour and forty minutes of time was saved by the train obtaining permission to remain on the main line. Working time for this train has been saved every week since it was fitted up and provided with means of constant communication with the despatcher's office. All of the wrecking trains have now been equipped with these instruments, so that after being ordered out they are in communication with headquarters until the wreck is cleared away and the train returns.

The committee appointed to fix the time and place of the next meeting reported in favor of holding it at Atlanta, Georgia, on the third Wednesday in October, 1889.

Messrs. Lockard, Leonard and Darlton were appointed a committee of arrangements for the next meeting.

Mr. R. W. Pope was granted permission to address the meeting in order to call attention to a misunderstanding which appeared to exist in regard to the work of the association. He alluded to the fact that the application of electricity to railroad work was continually increasing, and pointed out that it would be for the best interests of its members to give greater attention to these matters in order to make their meetings more profitable and keep abreast of the improvements which were continually being brought out. His attention had been called to this subject by the appearance of an article in the *Railroad Gazette*, describing an incandescent plant which had been introduced in the railroad yard at Oakland, Cal., for lighting the signal lanterns by electricity, which had proved to be more economical for the purpose than oil. He stated that a similar plan was in contemplation by the Penn. Railroad Company for the Jersey City yard.

A discussion followed upon this subject which led to the adoption of the following resolutions :

Resolved, That the chair appoint a committee of five on electrical information, whose duty it shall be to disseminate matters brought to their attention by members of this association.

The chair appointed to serve on this committee, Messrs. Leonard, Lattig, Bogart, Swift and Higgins.

Resolved, That the chair appoint a committee of three who shall select subjects and writers upon the same, said papers to be read at the annual meetings.

The chair appointed as such committee, Messrs. Herr, Selden and Lang.

Following out the line of policy as intimated by the previous discussion, Mr. G. L. Lang presented the following paper on "Electric Welding," as being a subject of general interest to the mechanical departments of railroads, as well as the electrical.

ELECTRIC WELDING.—BY OTIS K. STUART.

THE process of electric welding, which was discovered by Professor Thomson some 11 years ago, while lecturing at the Franklin Institute of Philadelphia, has been developed in the past two years to a far greater extent than is generally supposed. We started in with the welding together of small wires of iron and copper, and have been so successful in the development of apparatus, that we are now able to weld bars of a very large size and of almost any shape or metal.

The principle involved is that of forcing through a conductor an amount of current which the conductor will not carry without heating. Any conductors when placed in abutment, have as their point of greatest resistance the point of abutment or contact, and consequently it is at this point that the heat is first generated; and as is well known, this heat increases the resistance of the conductors at that point so greatly, that more heat is developed at a remarkably rapid rate.

A consideration of the above facts will prove at once one of the advantages of electric welding, as practiced by Professor Thomson, namely, the localization of the heat to the points or point at which it is desired, thus saving an enormous amount of energy which is usually wasted in welding with the forge or flame. So absolutely is the heat localized, that pieces of iron 3" long and an inch in diameter, can be welded together and then held in the hands for some time without any danger of burning, the only heat which is felt at all being that which is conducted along the metal to the hands after the welding is completed.

A further consideration of these facts, will also demonstrate that it is possible by the Thomson process to weld any metal, including even those which melt at a very low temperature such as lead, zinc, and tin, and those which melt at enormously high temperatures, as for instance, iridium, platinum, etc. Of course it goes without saying that we can weld any of the metals used in ordinary manufacture.

It is plain that if the heat is developed so rapidly, a very deli-

cate means of controlling it must be provided, and we are glad to say that we have been able to provide arrangements for this purpose which are almost absolutely perfect,—I am inclined to say absolutely perfect, for the reason that the control of the current can be made entirely automatic.

We are able to take a bar of inch iron 4" in length, raise it to a dull red in 20 seconds and hold it there for an indefinite period; to increase the heat to a bright red in a very few seconds and hold it there; then to still further raise the temperature to a welding or vaporizing point, in a remarkably short space of time; this indicates the delicacy of this apparatus, and I would add that no very great skill is required to operate the machine, a boy learning to weld iron and steel with great facility in a week or two. The time required to weld metals, depends, of course, upon the power of the apparatus and the skill of the operator. We have made strong and practically perfect welds in half-inch round wrought iron in six seconds; in inch round wrought iron in 45 seconds; and so on. Experiments have proved to us, that the power required to weld is proportional, or very nearly so, to the area of cross-section of the pieces; this is true of nearly all the metals, though, of course, the relative resistance and welding temperature of the several metals may interfere with this ratio.

For welding small wires such as telegraph or telephone, and the smaller sizes of electric light and power lines, the power required is very small indeed; the momentum of heavy machinery being more than enough to effect the weld. In this connection I desire to say that we are now working to perfect an apparatus for welding telegraph, telephone and electric light wires, and lines of pipe on the line. Our experiments in this direction have been successful, and we now think it possible to construct an apparatus which will be capable of being moved about by one or two men, and which will make joints in wires correctly and durably, the energy used being supplied by storage battery or batteries, forming a welding outfit. For repair work and in general construction it is our belief that this apparatus will be found very useful and effective; in fact we hope to do away entirely with the ordinary solder and link joints used at present.

The cost of such an apparatus will be very slight, and there would be a small royalty of a definite amount per 100 or 1,000 welds, as the case might be. This policy of placing an apparatus on the market has been adopted for the reason that our patents cover not only the apparatus for electric welding, but the art or process as practiced by Professor Thomson. It is hardly necessary to add that by the same process, we can solder and braze and anneal, and temper, and do other heating, local or otherwise, which cannot be done economically by present methods. All these operations can be performed with the same apparatus, though, of course, it is better to have machines specially constructed for particular work.

At the conclussion of the reading Mr. Lang stated that he had seen one of these machines in operation when a bar of cast steel and one of copper were welded together. One would suppose that the metal most easily fused would burn away before the other was brought to a welding heat. This is not the case, however, and it is very simply provided against. The current is brought to the bars through clamps which grasp the bars near to the ends to be welded, and the current is brought through these clamps. Where copper and steel are to be welded together, the clamp is placed about 6 inches back on the copper bar, while it is only about one inch from the point of contact on the steel bar. In this case the heat is diffused through a large body of the metal which is most fusible, so that they are both brought to a welding point at the same time. The process is something really wonderful, and promises to revolutionize the ordinary method. In reply to an enquiry by Mr. Lattig, Mr. Lang stated that the system is now in constant use at the Thomson-Houston factory in Lynn.

On motion of Mr. Lang, a committee of three was appointed to draw up suitable resolutions of thanks for the many courtesies extended to the association during their visit to New York city. The committee was composed of Messrs. Selden, Lang and Jones.

By permission of the meeting, Mr. F. E. Kinsman read a paper on an electric automatic brake-controlling device, which he claimed, would make the existing air-brake and block signal system still more effective than they now are.

The paper was referred to the committee on electrical information.

The meeting then went into executive session, and subsequently adjourned, to meet at Atlanta, Ga., October 16th, 1889.

.... An invention is essentially the product of the age in which it appears; a necessary consequence of the inventions and discoveries which have preceded it.—*Silvanus P. Thompson.*

.... If we look at the real nature of all commercial transactions, we shall find that the real thing which is the subject of a trade, lies back of the material thing to which the price is affixed, and rests in the ideas which are embodied in it and are expressed by it, and through which some physical fact or law of nature is made serviceable to man.—*Chauncey Smith.*

HIGH POTENTIAL SYSTEMS BEFORE THE BOARD OF ELECTRICAL CONTROL OF NEW YORK CITY.

At the meeting of the board, June 8, Commissioner Gibbens read the following letter which appeared in the *Evening Post*, signed by Harold P. Brown, "electrical engineer," 201 West 54th street, New York.

To the Editor of the Evening Post:

Sir:—The death of the poor boy Streiffer, who touched a straggling telegraph wire on East Broadway on April 15, and was instantly killed, is closely followed by the death of Mr. Witte in front of 200 Bowery and of William Murray at 616 Broadway on May 11, and any day may add new victims to the list. After every such accident the newspapers clamor to have the wires placed underground, while the electricians connected with the system at fault hold their peace or throw the blame on the telephone wires, until the matter has been forgotten. As an electrical engineer I know that burying the wires would not remedy the trouble, though it would largely diminish the risk, while the enforcement of a few common-sense regulations would make it almost impossible to kill a man from an arc light current. It will not do for electricians to state that they "don't know what killed that man," for unless they take prompt measures to make their business safe some terrible accident will cause the adoption of laws to regulate electric lighting, which, being framed by their enemies, will cripple or destroy their business.

So, at the risk of offending some corporations having heavy investments in unsafe systems, I will venture to state a few facts which I trust the press will be kind enough to publish widely, as no disinterested electrician will deny my statements.

It is well known that a continuous current of "low tension," such as is used by the Edison company for incandescent lights, is perfectly safe as far as life risk is concerned. From this fact the false popular impression has arisen that all incandescent systems are safe and all arc systems dangerous. But it is not to the "low tension" alone that this current owes its safety, since a factor fully as important is the even, steady quality of its delivery. That is, a current of "high tension," but unbroken and continuous, *may* be perfectly safe if properly operated, while a current of lower "tension," but wavy or pulsating, is *always* dangerous. And when these pulsations rise in speed and intensity the danger increases, until the climax is reached in what is called "alternating current" in which impulses are given first in one direction and then in the other several thousand times a minute.

To understand the reason for this it is necessary to remember that when a current through a wire or other conductor is made or broken, a current in the opposite direction is "induced" in any parallel conductor; the same effects are produced in a less degree when the first current pulsates, but are intensified when it is alternated or reversed in direction. Any one who has held the metal handles of a "medical" (Galvano-Faradaic) battery, has had a practical experience of the power of induction and pulsation; in this apparatus the current from the battery itself is so feeble that it cannot be detected without the use of instruments, except by the metallic taste when the terminals are touched by the tongue. This insignificant current is passed through a short piece of insulated wire coiled around an iron core, and is interrupted by a rapidly vibrating armature, thereby inducing in another and longer coil of wire surrounding the first a series of shocks whose intensity can produce most intense suffering or even death in a human being who forms a portion of the circuit. It is this rapid succession of shocks that kills, while a single steady impulse of the same intensity would do little damage.

Two of the leading arc-lighting systems have dynamo-electric generators provided with what are known as "open-circuit armatures," which produce a pulsating current somewhat similar in kind to the one just described, though a thousand times more powerful. It is to this current that nearly all the deaths caused by arc lighting systems must be attributed. These "open-circuit armature" systems, were pioneers in electric lighting, and at the time they were invented it was supposed that the "closed-circuit armatures," which produce the steady and safer current, could not be made to develop sufficient electromotive force to operate a number of arc lamps upon one circuit. But the recent advances in the science have made possible "closed-circuit armature" generators which give the same amount of current and electromotive force, with a much less expenditure of motive power, so that there is now no valid reason for the existence of the old type with its pulsating and dangerous current.

I do not mean to have it understood that the "steady" current is always safe or that the "pulsating" is always unsafe, for any current with more than 50 arc lamps in series is dangerous and should be prohibited; while the "pulsating" current, if its circuit is kept thoroughly insulated and carefully watched, and tested every day, may run for years without a fatal accident. But the fact remains that the "steady" current, with 50 or less lamps in circuit, has had, to my knowledge, but four victims against the scores killed and maimed by the "pulsating" current. And even these four were responible for their fate, since all were employés and should have known better. Three of them tried to disconnect apparatus through which they knew the current was flowing, and thus got into the circuit, while the fourth received the full current while trying to repair a broken wire which he knew was charged.

But the persons killed by the other system, as a general thing, have been in no way responsible for the accidents that caused their deaths; they have, as did young Streiffer, touched or run against an apparently harmless wire when standing on a damp place, or have touched at the same moment some metal accidently charged with the fatal current, and some other conductor having a "ground" connection, as did Mr. Witte. I do not believe with extremists that the "pulsating" current should be prohibited, but I do think that the conditions of safety should be rigidly enforced by the authorities.

If the circuit carrying the "pulsating" current is perfectly insulated at all times, no accident is likely to occur. But if, through wearing of the insulation or a heavy rain, a connection between the circuit wire and the "ground" is formed, any one who touches the wire and a "ground" will receive a portion of the current; if he happens to be near the other "ground," he receives but a small shock, but if there are a number of lamps between him and the other connection, the shock may be fatal.

Of course the reply will be made that all the arc lighting stations in this country use insulated wire, "as required by the underwriters," but here is just where a great mistake has been made, and the sooner this is corrected the better for the cause of electric lighting. It is an open secret among electricians that the wire known as "underwriter's wire" has a very poor insulation, even when new and during dry weather, but practically no insulation at all during a rain. The paint dries out of it after a few months' exposure, other wires rubbing against it soon wear away the cotton and expose the metal, and it is altogether unfitted for outdoor use. Among electric lighting men it is appropriately called "undertaker's wire," and the frequent fatalities it causes justify the name.

Even with the most conscientious electric light superintendent, who tests his circuit carefully for "grounds" every day, before starting the generators, there is no surety that during the run some telegraph wire may not drop upon his circuits, wear away the insulation, and set a death-trap for the unwary who may be miles away from an electric lamp.

The condition of the electric light circuits in the lower part of the city is simply disgraceful, as has been previously pointed out. Most of them were first put up years ago; they have been cut and patched until full of joints, from which the tape flutters; the insulation is entirely worn off in places or hangs in shreds, and few circuits are fit to run with safety for a single hour. They cross and recross the structures of the elevated roads; they sag and sway in loose loops, and are intersected at all levels by telephone and telegraph wires. On some of these circuits two or more dynamos are run in series, thus more than

doubling the life risk, and it is almost certain that it was these overloaded circuits that killed Streiffer and Witte.

If the Board of Electrical Control cannot force the wires underground, they can at least condemn these lines, which the companies can afterwards utilize by reinsulating for their underground circuits. The underwriters ought to have an eye to this also, for every bare or poorly insulated spot is a menace to property as well as life.

But if "influence" prevents the wires from being replaced, and it seems to permit the extension of new wires elsewhere, there are a few simple precautions which, if enforced, will make fatal accidents almost impossible. All the deaths due to arc lighting, as far as reported, have been caused by the victim breaking the circuit and placing himself in the break to receive the fatal "extra-current" thus caused, or by his making a "ground" connection with a circuit on which there was another "ground." Both of these dangers can be avoided by very simple apparatus.

If a voltameter, or a circuit of very high resistance, be connected across the poles of every arc light dynamo, the external circuit may be opened without producing the death-flash, as most of the "extra current" will go through the by-pass. This would prevent a large proportion of the fatal accidents. If every arc light dynamo was also provided with a wire of very high resistance leading from the circuit to the "ground," upon which was interposed apparatus to shut off the production of current the instant a second "ground" occurred, no deaths could be caused except by foolhardy carelessness. The latter apparatus could also be used to shut down the current in case the external circuit should be broken.

With these precautions, and with the number of lamps limited to 50 on a single circuit, even the "pulsating" current would be fairly safe, but as the stations are now operated upon circuits with frayed and worthless insulation they are a constant menace to all who walk the streets, use a telephone, or touch a wire.

In regard to the popular impression that all incandescent electric lighting systems are safe, I am sorry to say that recently several companies who have more regard for the almighty dollar than for the safety of the public, have adopted the "alternating" current for incandescent service.

If the pulsating current is "dangerous," then the "alternating" can be described by no adjective less forcible than *damnable*. With the "pulsating" current three contingencies must ordinarily arise to produce fatal results: there must be a "ground" connection on the circuit; a person must touch the circuit at some distance from the first "ground," and must at the same instant be in connection with the "ground" himself. But the "alternating" current produces fatal results by simply touching the two parallel wires, always close together, connections from which enter every house. Its supporters may say that on account of its danger they do not permit the "primary" or death-current, to enter the house, but supply the lamps from the "secondary" current. True, but between these two circuits is interposed nothing more than a thin layer of cotton or silk insulation, and, as happened again and again, it requires but a flash of lightning or a little moisture in the converting apparatus to bring the death current to each lamp.

The only excuse for the use of the fatal "alternating" current is that it saves the company operating it from spending a larger sum of money for the heavier copper wires, which are required by the safe incandescent systems. That is, the public must submit to *constant danger from sudden death* in order that a corporation may pay a *little larger dividend*. I do not know of a single disinterested electrician of high standing who does not condemn the alternating system. Siemens and Halske, a firm of electricians with a world wide reputation, have spent years of experiment upon it, but have abandoned it as unsafe, and say that its use should be prohibited by law.

Following the example of Chicago, the Board of Electrical Control should forbid the use of the fatal alternating current, and legislatures, city councils, and life insurance managers should see to it that stringent laws and regulations be passed to prevent this wholesale risk of human life. The placing the wires of the alternating system underground would only intensify the danger in houses where it might be used, while its use with underwriter's wire in a city like this is as dangerous as a burning candle in a powder factory. If the death of these three men can effect the adoption and enforcement of regulations similar to the following, they will not have died in vain.

RULES FOR STATION LIGHTING.

Not more than 50 arc lights shall be operated upon any one circuit, unless said circuit is used exclusively for street lamps mounted upon wooden poles; in this case the number must not exceed 60.

All out-door arc light circuits must be provided with waterproof covering having an insulation resistance of not less than one-half a megohm. Any circuit falling below this must not be used until restored.

No arc light dynamo shall be operated unless provided with a voltameter across its terminals, or other device, to provide a path for the extra current caused by opening the external circuit.

No arc light dynamo shall be operated unless provided with means for automatically stopping the production of current the instant a ground connection is made upon its circuit.

No arc light dynamo shall be operated unless provided with means for automatically breaking or short circuiting the field circuit the instant the external circuit is broken, in order to prevent a current from being built up by the broken circuit ends falling upon some conductor.

No alternating current with a higher electromotive force than 300 volts shall be used.

HAROLD P. BROWN, Electrical Engineer,

New York, May 24. 201 W. 54th street.

After the reading of the above, commissioner Gibbens moved the following resolution which was adopted unanimously:

Resolved, That the rules suggested by Mr. Brown be published in the minutes; that marked copies be sent to the superintendents of the different electric light companies of the city, to the Westinghouse company, which proposes to use alternating currrents, to Mr. Park Benjamin, who drew up the rules and regulations of the commission, to Mr. Ralph W. Pope, who has frequently aided the commission by his advice, to Professor Plympton, of the Brooklyn commission; and that accompanying the marked copy of the rules as proposed by Mr. Brown, the secretary be directed to invite the attention of these gentlemen to these proposed rules and regulations, and to ask them to give the board such a reply on the subject as they may see fit, either in writing or by appearing before the board to discuss the matter; and that in order that Mr. Brown may have a chance to meet with these gentlemen, if he so desires, that the same be sent to him.

Invitations were extended to the various lighting companies interested, as provided in the resolution, and a day appointed for the hearing of arguments as to the necessity of adopting the rules proposed by Mr. Brown. The meeting was held in the lobby of Wallack's theatre, on July 16, about 25 persons were present.

Upon the calling of the meeting to order, commissioner Gibbens announced that the board was ready to listen to all who were interested in the subject. Communications were then read before the meeting as follows:

608 Chesnut street.
PHILADELPHIA, PA., June 12th, 1888.

WM. H. BROWNE, Esq.,
New York city, N. Y.

Dear Sir;—Your favor of the 9th to hand, in which my attention is called to an article in the New York *Evening Post* of June 5th, 1888, headed, "Death in the Wires," signed by Mr. Harold P. Brown, Electrical Engineer, which contains some very sweeping assertions, and also lays down the law in a manner, to which I am sure no practical electrical engineer would commit himself.

Mr. Brown's statement that no disinterested electrician will deny his statements, I think is very correct. Some of his statements are hardly worth denying, and it is only the fact that they are apparently published in the interests of a particular corporation, and for the purpose of taking advantage of the fears of an uninitiated and justly anxious public, that makes it worth while to answer any of them.

If Mr. Brown had confined himself to showing that the three deaths he quotes were all caused by neglect of the commonest precautions, he would have done far better service than by entering into a quasi-scientific disquisition which the general public cannot understand, and which is so full of absurdities as to show that he has either the little knowledge which is so dangerous a thing, or is a deliberate attempt to make a good case by false inferences. The one point plain in his article is that the system of one particular company is perfectly safe and the systems of all others are dangerous, and that one in particular should be wiped out of existence. One of the deaths which Mr. Brown cites, that of Mr. Witte, was reported as caused by a "closed circuit" "shunt wound" machine, the very one which he calls the "steady current" which "has only four victims against the scores killed and maimed by the pulsating current," the fact being that the "pulsating current" has tens of thousands of arc lamps where his much boasted "steady current" has thousands. It is as though he had claimed that only four men had been killed while traveling on horseback in New York city, while scores had been killed on the elevated roads—therefore, it is safer to ride horseback than by railroad.

I have been running electric lights, both arc and incandescent for the past seven years, and have never known of a case where it was conclusively proved that a man was killed by the electric current without there having been gross carelessness in some direction. Mr. Brown could very easily account for every death that has occurred in New York (as far as I have been able to follow them) by the condition of the wires alone. Any man who would undertake to run belts carrying thousands of horse-power, even in a factory, where none but skilled help are employed, in the unprotected way in which wires are run overhead in New York city, would be universally condemned. I never walk in the streets of New York, but my blood boils to see the criminally dangerous and reckless manner in which wires are strung through the streets. They are placed, not on poles, but mere stumps; and wood exposed to the weather, seems to be considered a good enough insulator. The so-called underwriter's covering seems to have been originally the standard, and even that is worn off in many places for several feet along the wires, while the whole air is full of dead and rotten telegraph, telephone, burglar alarm and district call wires, any one of which by falling across an arc light circuit, becomes itself as dangerous. It is absurdity for Mr. Brown to talk about lighting stations and "simple rules and precautions" to be enforced therein. No precautions at the station, however valuable they may be in themselves, can render electric lighting safe, when the outside circuits are in this condition.

It is this outrageous and inexcusable carelessness which has led to the cry for "underground wires," a cry which has so much real foundation that we may well excuse the often rabid insistance of its utterers. The fact that the wires are in this condition in the largest city in the country, is taken as proof that they are in a similar condition in every city, and cannot be made safe, and paper after paper reiterates the senseless shriek against the horrible danger of overhead conductors, without any reference to the manner in which they may be installed.

An overhead wire with properly soldered joints and water proof insulation, with insulated tie wires, and kept clear from all ground contacts on buildings or trees, and out of reach from the ground, is as safe as any underground conductor that can be made, except in case of damage caused by fire, storms or external violence, in which cases the underground conductor has such an overwhelming advantage, that this plea alone should be sufficient to cause them to go underground.

I am an earnest advocate of underground wires and an interested one, but the claim that wires are dangerous, simply because they are overhead, will only hurt the cause, for that reduces it to the level of the outcry against the introduction of railroads, or gas, or any new improvement. There are enough fair arguments against overhead wires without resorting to clap-trap or trickery.

If Mr. Brown kept himself posted as any one who wishes to pose as a general electrical teacher should certainly do, he might have noticed a report in one of the electrical papers of a painter who fell from the roof of a building in Pittsburgh, and who saved his life by catching hold of the two opposite leads of an overhead circuit carrying one thousand volts of alternating current, by which he hung until taken down unhurt with a ladder. This is what I call good practice in overhead construction. High insulation and such solid work that your wires can stand the strain of a man falling twenty feet onto them, without tearing them loose.

Now for Mr. Brown's attack on what he has been pleased to call the "damnable alternating current."

He evidently has not had the least experience with the alternating current as applied to electric lighting, and his information seems to have been derived chiefly from a gratuitously circulated publication of the corporation, the sale of whose particular apparatus is most affected by the alternating system.

In spite of all that has been said on this subject in the past year at the various electrical conventions, in spite of the published descriptions of the various converters manufactured by different companies, without taking the trouble to inform himself by actual inspection of a single converter, he again repeats the statement which I can characterize as nothing but the grossest ignorance of electrical manufacture, or a deliberate falsehood, that between the two circuits in a converter "is interposed nothing more than a thin layer of cotton or silk insulation," and he says "that as has happened again and again, it requires but a flash of lightning or a little moisture in the converting apparatus to bring the "death current" to each lamp," showing his utter ignorance of the whole subject, not to know that in the first place only the lamps of one group would be affected, and they would only be affected by being extinguished, for in such cases the safety fuses would instantly melt and cut off the current. A more contemptible evasion of the real question at issue I have never seen than his reference to Messrs. Siemens and Halske, as opponents of the alternating system. Messrs. Siemens and Halske abandoned the manufacture of alternating current apparatus for the same reason that Westinghouse abandoned their apparatus after having tried it, namely, because they could not make commercially efficient apparatus which would not overheat and burn up, and the fact is that Siemens and Halske are to-day making and selling the underground cables for alternating current work in Europe. These cables have one conductor in the centre surrounded by an insulating material; the other conductor is wound on the outside of this with a second layer of insulating material, and the whole is then covered with a sheathing of steel tape, and Messrs. Siemens and Halske recommend and guarantee these cables for use with an alternating current of 5000 volts.

He says that he does not know of a single disinterested electrician of high standing who does not condemn the alternating current system. His acquaintance with eminent electricians must be limited. Why did the Edison company secure the control of the Zipernowski system as soon as the Westinghouse had made a market for the alternating current in this country? Why did the United States company secure the Jablochkoff system for the same purpose? Are not Ferranti, E. J. Houston, Elihu Thompson, men of high standing? Truly, these men are all interested; but who are disinterested electricians nowadays? Professor Forbes, of England, is usually referred to as probably one of the best posted men and the most thoroughly disinterested electrician of the day, and I, myself, heard him say at the electric light convention, held last February in Pittsburgh, that the alternating system as installed in America, made him feel that we were far ahead of anything they had done in England, and that he had completely changed his opinion, and was now satisfied that the alternating system was safer than any direct current of the same tension could be. For people who have absolutely no experience with electric lighting by alternating currents to refer to speeches made five years ago by electricians, however eminent, is folly, when we recall the history of the alternating system in this country. First, it was an impossibility. Then this was limited to its being a commercial impossibility, and when its adoption showed that it was a success, every pettifogging self-styled electrician, who had been engaged in proving it ridiculous, turned his attention to proving that it was old, and that everybody knew about it years ago, and the very companies, who had been ridiculing it, both publicly and privately, turned their attention to foisting on the public the most unblushing and slavish imitations of the successful form of this apparatus, which is meeting such success in this country, and which has excited the unqualified admiration of European electricians.

Now the fact is that it has been proved in a dozen cases that the alternating current, while disagreeable, is less dangerous to life than a direct current of the same tension. Personally I have received the full 1,000 volt current from an alternating current machine, not once, but half a dozen times, and I have received the direct current in the same way, and, while the direct current will always make one sick for some time after the shock, the alternating current leaves no such effects. I have seen five or six men get this 1,000 volt alternating current shock direct from the machines. I have pulled one off who was hanging to the bare switch-board wires and whose hands were badly burned, but who in half an hour was at work again, having in the meantime walked by himself to a doctor to have his burns dressed. Add to this that this high tension current is thoroughly insulated and protected from the house circuits by layer after layer of insulating tape, mica, fibre, and by an open air space, and one can easily see that the danger of high tension reaching the house is very remote indeed.

Mr. Brown has chosen to exhibit his ignorance and bias by speaking of lightning bringing the high tension into the house; that is to say, the lightning to enter any one house by the alternating current wires, has to break down the whole insulation of the converter, while the direct metallic connection on the system which Mr. Brown is pleased to favor brings the lightning itself, with its tens of thousands of volts, direct to every lamp on the system, without the slightest check or hindrance. Yet how many people have been killed by lightning coming in on such wires? No one that I have ever heard of, and Mr. Brown knows that this danger is infinitesimal, or he is merely truckling to the prejudice in favor of direct current systems, when he makes any such statement.

He spoke of the Chicago board having forbidden the use of the "fatal alternating current." I presume he means the same board whose inspector read a paper before the Chicago Electric Club, in which he showed the induced discharge from a simple magnet as an instance of an alternating current. They will simply have to abandon this position. Would it not be a good deal more sensible to follow the example of the Philadelphia board, which has simply placed the very strictest regulations (and what is a different thing, enforces them) as to the use of not merely alternating current apparatus but of all apparatus, and came to this conclusion after a thorough inspection and test of the insulation and general construction of the alternating current converters.

When Mr. Brown styles himself "An Electrical Engineer" he lays himself open to the pertinent inquiry, What has been his experience? What was his education on the subject? With what companies has he been engaged? What work has he done to which he can point with pride as a specimen of careful work? Is not this the same Mr. Brown of the "Brown Converter," who endeavored strenuously for two or three years to convince the various arc light companies of the country that it would be a great benefit to the public at large and to their dividends (for which he now expresses such a lordly contempt) to carry a 3,000 volt current for incandescent lighting into houses and stores by means of an apparatus of his own devising, and which was designed to occupy the very field now taken by the alternating current system? It is curious that he should apply to the alternating current system the very expression which was applied to it by one of the salesmen who was trying to induce me to adopt the "Brown Converter" for house lighting on arc circuits, that "this damnable" alternating current system was just "wiping out apparatus" like theirs "all over the country." Can it be possible that a distinguished electrical engineer, like Mr. Brown, could allow himself to be swayed by any such trifle as this? Let us trust not. Yours, truly,

T. CARPENTER SMITH.

THE HONORABLE, THE BOARD OF ELECTRICAL CONTROL.

Gentlemen:—In the New York *Evening Post*, of June 5th, there appeared an article by one Harold P. Brown, electrical engineer, upon the dangers to be expected from electric lighting apparatus. This I have read, and carefully noted his suggestions to your board regarding certain precautions which he claims should be observed. It appears to me that the article is hardly written in a fair spirit, and that many of the comparisons are obviously unjust and incorrect, and the suggestions impracticable.

In the first place the current from open coil armatures is referred to as "pulsating" and "death dealing" and is described as being much more fatal to human life than the current from a dynamo having a closed coil armature. It seems to me that this is purely and simply a matter of conjecture on the part of Mr. Brown.

I have tried many times to distinguish between the physiological effects of this so-called pulsating current and those caused from a closed armature. I have used in all cases sufficient resistance in the main line to give a difference of potential of from 60 to 200 volts. The sensation experienced in each case is precisely the same as is the effect upon the needle of a delicate galvanometer, which will stand perfectly still when under the influence of a current of either character from a properly constructed machine. No doubt but a voltage of 2,500 *would fatally* injure any person introduced into the circuit, but the idea that the effect of the open coil armature current would be many times that of the closed coil would be merely guess work, for I do not consider we have any reliable data to work from.

Assuming there have been more unfortunate accidents upon circuits operated by dynamos of the open coil class, what do they prove? It is well known that these dynamos can carry more lights and consequently a higher potential than the other style, and who

can say that Mr. A. and Mr. B. would have lived had a shock of the same voltage come from a dynamo of another type. One thing is certain, viz.: that there have been fewer fatalities resulting from the electrical current than from steam or other motive power. It is stated that but five men have been killed in New York during the past 10 years.

Mr. Brown compares the alternating current as produced by dynamos, with that emanating from what is generally known as the medical coil. He, as an electrical engineer should know that they are in no manner similar except that they both are bi-direction currents. In the first place the current of the ordinary medical coil capable of throwing a spark one-sixteenth of an inch in length, is immensely greater in pressure than that of the 1,000 volt generators now in use which are incapable of striking through an air space of even one-hundredth of an inch; and again, the current in a medical coil is produced by a direct current being made and broken, inducing currents of tremendous pressure—of but little volume in the secondary. The unpleasant feeling caused by this current is directly traceable to what is known as the extra current, caused by the rapid changes in quality of the magnetization of a core of iron upon which the coil is wound as well as the self-inductive effect of the coil itself.

With the alternating current the case is materially changed. A very small amount of wire is revolved in the field of force which is absolutely constant and is not affected in the least by changes in the external circuit. The amount of potential is predetermined and controllable. There is no self-induction of any moment, to produce the dreaded extra current; and opening the circuit or introducing one's self into it, merely subjects one to the pressure of 1,000 volts which has never yet proved fatal. There is no extra current and no kick from the field magnets.

But in supplying incandescent lights from alternating current circuits, it is not customary, for many reasons, to introduce the high pressure wires into the interior of the buildings. Between the primary circuit and the house circuit a transformer is interposed which effectually changes the character of the current from one of 1,000 volts pressure to one operating but 50 volts.

Mr. Brown states that there is but a thin film of cotton or silk between the primary and the secondary windings of the transformer, and that this is liable at any time to be ruptured by a flash of lightning. This shows that he is totally ignorant of the construction of alternating current apparatus as well as the method of installation adopted by the leading persons in the business.

I am familiar with various methods of protection used, and have no hesitation in stating that when such as I shall describe, which have been adopted by the Thomson-Houston Electric Co. are carried out, there is no possibility of a high potential affecting persons through any accidental contact with the secondary wires. In the first place, this company operates its dynamos at a potential of but 1,000 volts, as against 1,800 or 2,500 used, and, so far, with safety for the past two years in many places abroad. For every installation of transformers a lightning arrester is used which is absolute in its action and effectually prevents any ill effects to the transformer from a lightning stroke upon the line. I have never known one to fail yet. Then the primary winding is separated from the secondary by a very substantial section of insulating material thoroughly dried and shellaced, and finally, the secondary or interior circuit is soundly connected to the earth. Where is there any danger now? Even if the high potential were to get upon the secondary line, what possible harm could be done? Suppose the primary line in a first-class condition and the secondary properly grounded as described; also the accidental contact upon the primary and secondary. A person touching the secondary, and at the same time making contact with the earth, would be affected in what manner? Not at all. Why? Because there is no complete circuit. But go further, and suppose a ground upon the primary as well. A person touches the secondary and again there is no effect. Why? Because there is a complete shunt about his body caused by the earth and the ground connections, and even if the transformer were not instantly cut out of the circuit, all the current would go by a shunt which is of no resistance and would not influence the man at all. Why should Mr. Brown be so set against the high tension alternate current when it has been in successful operation for so long a time, and which even under the worst conditions could but introduce a potential of 1,000 volts upon a few lamps at a time? It is not consistent, because we find about a year ago a description of "The Brown Automatic Converter," a modification of a device to be used in running incandescent lights from arc current circuits "without involving a large expense for incandescent lighting plants, or the necessity of getting a large number of subscribers to commence with; and also valuable to incandescent lighting companies for customers too distant for the ordinary incandescent circuits."

Why are no charges made here against incandescent circuits, which must be considered extraordinary? Surely no man so careful for the safety of a general public would advise the use of such an arrangement which is liable at any time to bring a difference of potential as high as 3,000 volts into a man's house, and this pressure too of a dynamo producing a "deadly pulsating" current, for we read in the advertisement in capitals "CAN BE USED WITH ANY MAKE OF ARC LIGHT DYNAMO." To say the least it looks very curious, and one is inclined to read between the lines when noting an "electrical engineer" stand forth in condemnation of the one successful, commercial method of introducing the electric incandescent light and stating that the use of 300 volts of alternating current is dangerous, but implying that the operation of incandescent lights upon 3,000 volt current circuits is not to be condemned when in conjunction with the converter. Let us take up his letter again and turn to the suggestions.

In order to discover the presence of grounds upon the line he advises the use of a permanent ground connection at the station.

Inquire among station superintendents and see how many of them agree with him. In order to keep a line in condition we are told to subject it to a constant strain at every insulator and contact point. Is this wiser than the present method pursued by all properly governed companies? viz.: To test the circuits every day and to keep them free from grounds. Also to shut down should any vicious connection occur during the night. There is a station in this city which is constructed on sound principles. The wires are well insulated and well run, and there has not been a ground on a circuit for weeks.

Again we are told that to prevent the flow of the extra current through the body of a person introduced into the circuit, we are to place a voltmeter or high resistance about the dynamo terminals. Very well, do so and what will you have? Evidently the resistance must be high in order that too much current may not be going to waste; now will not the "death stroke" divide itself according to the law of shunts, and will not the person get a good share? If the resistances were constructed as a coil I am not sure but its effects would be practically useless, and until it is definitely known whether it is the prime potential or the after current which kills we had better pay more attention to the exterior lines and construction and less to such traps.

And again we are to provide a means for automatically shunting the fields when the external circuit is opened. There is more merit in this than in the other schemes; but I do not believe any device could be made sufficiently sensitive to operate in time to prevent any person opening the circuit, and at the same time not to interfere at improper moments.

As there are so many simple and effective methods for determining when the circuit is broken, it does not seem wise to make any such law.

The reference to the Siemens company is not bad. It has been published in several papers in New York and Boston and always in the same words. Investigation shows that the company referred to never did make a business of manufacturing alternating apparatus other than a dynamo, which is to-day made by them and for sale in Europe. Perhaps the reasons they did not manufacture can be found in the records of the patent office, or may be Rankin Kennedy's articles on alternating current apparatus would prove of assistance to those desiring a partial idea of the true state of affairs abroad. The position of Chicago and its inspector is well known.

We read last that the "damnable" alternating current should not be permitted in higher voltage than 300, and that if the proposed rules are adopted three men shall not have died in vain. It can only be said that most of the rules, as well as the letter, show under a philanthropic exterior a distinct bias; which perhaps may be accounted for when we recall Mr. Brown's connection with the American company whose dynamo has a closed coil armature. It would be interesting to read the opinions expressed by Mr. Brown when he was engaged in installing the plant of the Brush open coil system in Eau Claire, Wis.

A summary of Mr. Brown's paper may be made as follows :—

First.—The alleged comparison between the effects from a medical or Galvano-Faradaic coil and the alternating current dynamo does not exist.

Second.—The death dealing quality of the current from dynamos having open coil armatures is but conjecture.

Third.—Placing a shunt of high resistance about the terminals of the dynamo is impracticable, and would but partially compensate for the after or extra current.

Fourth.—It is not clear that death is caused by the after-current or "kick" of the machine. In fact it is probable that such extra current is not essential, from the fact that fatality has occurred from simple connection with a grounded wire.

Fifth.—A constant ground on a high tension dynamo in order to detect a second one is poor engineering.

Sixth.—A break in the circuit would be indicated by the performance of the apparatus in the station, and the one in charge should shut down without any further notice from a complicated device which might render steady commercial service questionable.

Seventh.—Under no circumstances should 300 volts be made the limit allowed alternating current service, because practical demonstration, extending over a period of two years, shows that where the proper protecting devices are used there is no danger.

In conclusion, the writer must suggest that in the action already taken by your board regarding overhead construction, is to be found the solution of the danger question.

Of course the electric current under certain conditions is dangerous, but no more so than steam plants or various forms of

motive power. What is needed is *control* and not *prohibition*. Look over the lines last constructed in your city, and note that any danger from them must be preceded by some accident not traceable to the installation or operation of the plant. A stone upon a rail may wreck a train. A boiler under 150 lbs. steam is subjected to greater strain than one with 50 lbs., but by strengthening the construction we keep the steam in. Follow rule No 2, suggested by Mr. Brown, and let us use better insulated wire. Whether it be Cowles' or Simplex, Trinidad or Bishop's makes little difference, but keep up the standard. The extra first cost of an installation even with the most expensive wire will not average more than five per cent. on the total investment, while the percentage improvement in dividend paying quality is not to be estimated. Respectfully submitted, S. C. PECK.

New York, July 12, 1888.

FORT WAYNE "JENNEY" ELECTRIC LIGHT CO.
FORT WAYNE, IND., June 29, 1888.

THE HONORABLE BOARD OF ELECTRICAL CONTROL,
New York city, N. Y.

Gentlemen:—The question of the danger of alternating currents in the present systems of lighting by incandescent lamps has been in the past a much-discussed one, both at the meetings of the National Electric Light Association as well as at the meetings of various scientific societies throughout the country, and the conclusions arrived at by those who are theoretically and practically competent to judge are that the alternating current is not dangerous by any means when used within certain limits of pressure and that the safety limit approximates 1100 volts electromotive force. After an extended practical experience of three years by those who have carefully followed the alternating systems in use, and after many physiological experiments, frequently involuntary ones, to determine the safe limit of pressure to work with, it has been found that no fatality can occur or serious inconvenience result from a shock from an alternating current having a pressure of that already cited, 1100 volts. It has been long and well known that in most cases where fatal accidents have happened with high tension continuous current systems, the death shock is received at the moment of breaking away from the circuit, not at the moment of completing the circuit around the body, the reason is obvious and two-fold, *viz.:* When you place yourself in a circuit in which there is flowing current at a dangerous pressure, the skin of the body, which has a very poor conductivity, in fact has good insulating properties, partly protects you from the danger shock, but as you will involuntarily make a desperate attempt to throw yourself out of circuit and succeed, at the moment of breaking away an arc will be set up, burning the body insulation (the skin), and freely entering the trunk cause paralysis of the respiratory organs, preventing thereby the blood from being oxidized. Death will then ensue unless instant remedies be applied, and right in the latter line, recently in France, the passage of an alternating current through the body has been very efficacious in restoring life. The other reason of the fatality referred to is, at the moment of breaking circuit, an electromotive force, far higher than was normally in the circuit, is developed, considerably aggravating the effect of the shock.

In an alternating current of the same dangerous pressure there will always be a much better chance of escaping a fatality than in the case just quoted, as in the first place the electrical impulses being equal and opposite, the effect of the normal electromotive force alone will be experienced, for at the moment of breaking away from the circuit when the pressure would have a tendency to rise, an impulse in the opposite direction, will instantly neutralize it, and the E. M. F. is maintained normal; again, the very nature of the current with the impulses equal and opposite also tends to suppress the arc at the moment of breaking, for the self-same reason as that which tends to maintain the E. M. F. normal, preventing the skin from being so badly burnt, and the current proportionately from free and dangerous passage to the vital organs.

The danger attending the use of converters has been referred to, chiefly, however, by those not familiar with their construction. We will admit for the sake of argument, that we have exceeded the safe limit of pressure in the converter, and let us see whether the dangerous current will or will not reach the users of the incandescent lamps.

I will premise what I shall say at this point by stating, and I have occasion to say so elsewhere, that two-thirds the difficulty is overcome when you understand its nature. Now in this case we want to prevent the dangerous current reaching the users of lamps, we know the current is dangerous, our practical experience has so informed us. The secondary coil in the circuit on which the incandescent lamps are placed is in the same iron receptacle as the dangerous primary coil which is connected with the primary circuit, and by the entrance of moisture or a discharge of lightning the organic insulation between the two coils might very readily give way, as it occasionally did in the earlier experimental stages of the work years ago; we should not, however, trust to any insulation to keep the current in the respective coils; in this case we simply introduce a conducting strip of copper or other metal between the primary and secondary coils in the box containing the converter, this strip being carefully insulated from both primary and secondary coils, as may be seen in the converter submitted for inspection.

Now what is the effect of the dangerous primary current, endeavoring to reach the secondary coil and circuit? It will be obvious that it will be intercepted by the interposed metallic strip referred to, and the current which might enter the secondary is diverted to a ground connection made with this strip. Should a lightning discharge enter the primary, it will surely go to ground, for which it has in all cases an affinity, seeking the passage of lowest resistance. Should a lightning discharge strike the house and the secondary circuit, and make an attempt to get on the line through the primary, again it is intercepted by the metallic strip and the integrity of the insulation between the primary and the secondary is maintained, no harm happening.

These precautions have been dictated by experience in the induction apparatus; and I may be forgiven when I say that any other difficulty which may present itself as time rolls on and the alternating systems develop in magnitude, will be equally carefully and successfully met.

As an instance of the unmeaning glibness of the speech of some of those who desire to constitute themselves authority on the subject, but who have never qualified in any practical form, speaking of the dangers attending the use of the alternating current, in the New York *Evening Post* of June 5, a gentleman states that the danger attending the use of alternating currents will not be decreased, but contrarily will be greatly increased by placing the conductors underground. It is evident that the gentleman has concluded that because with the underground low tension continuous system, great difficulty has been experienced in properly insulating to prevent troublesome grounds and disastrous leakages, that all other systems as a matter of course suffer similarly. In point of fact the low tension current at 220 volts in underground conductors offers a far greater strain upon insulation than a high tension alternating current at 1100 volts. It will be known that one of the functions of a current flowing through a conductor is a heating one, that the greater the current transmitted through a given conductor the greater the heat, or in other words, the heat developed is as the current squared into the resistance, $C^2 \times R$. It will further be known that with slow radiation, as must necessarily be the case with the conductors underground, the heating effect with a given current and cross-section of wire must be enormously increased. With low tension continuous current systems it frequently happens during the hours of heaviest lighting that a loss of some 20 to 25 per cent. is incurred in the conductors, and any person familiar with the temperature that a conductor attains at such a loss as this will not wonder at the trouble of the low tension system and the consequent strain on the insulation. On the other hand with the alternating current no such loss in the conductors need ever be permitted; throughout the hours of use it may, therefore, be comparatively cool, certainly never warm enough to prejudicially affect the insulation. The reason of being able to work at a low temperature in the latter case, of course, is that working with a current alternating in polarity, small in quantity and high in tension, we can afford to work at a much less waste of energy and corresponding reduction of temperature in the conductors; therefore, the insulation of the wires in the latter case need never be strained, the strain on the insulation by the use of the higher E. M. F. being more apparent than real. These conclusions have been arrived at by careful practical experiments that no amount of sophistical theorizing can refute, and are equally within the scope of all who wish to familiarize themselves with a few elementary facts.

By the use of the alternating current as now employed by companies long in the field, who have a reputation at stake, the electrical engineer has placed in his hands an electrical lever, so to speak, with which he may move the world, practically the greatest of all electrical developments of the age, of incalculable value and far reaching possibilities, and any objections to its use (and their name will be legion) by interested persons should be regarded and dealt with carefully and impartially as affecting something of immense public value as well as something of future public value that at present it is impossible to overestimate, and should not be too hastily condemned in consequence, by the utterances of the inexperienced.

Yours very truly, MARMADUKE M. M. SLATTERY.

OFFICE OF
RALPH W. POPE, Consulting Electrical Engineer,
No. 30 Temple Court,
NEW YORK CITY, July 9th, 1888.

Hon. THEODORE MOSS,
Secretary, Board of Electrical Control,
New York city.

Dear Sir:—I have the honor to acknowledge the receipt of a copy of the minutes of the proceedings of the Board, dated June 8th, containing a resolution in which my opinion is requested, regarding certain suggestions as to the amendment of the rules

of the Board, proposed through the public press by Mr. Harold P. Brown, which are as follows :—

RULES FOR STATION LIGHTING.

(1) Not more than 50 arc lights shall be operated upon any one circuit, unless said circuit is used exclusively for street lamps mounted upon wooden poles; in this case the number shall not exceed 60.

(2) All out-door arc light circuits must be provided with waterproof covering, having an insulation resistance of not less than one-half a megohm. Any circuit falling below this must not be used until restored.

(3) No arc light dynamo shall be operated unless provided with a voltmeter across its terminals, or other device, to provide a path for the extra current caused by the opening of the external circuit.

(4) No arc light dynamo shall be operated unless provided with means for automatically stopping the production of current the instant a ground connection is made upon its circuit.

(5) No arc light dynamo shall be operated unless provided with a means for automatically breaking or short circuiting the field circuit the instant the external circuit is broken, in order to prevent a current from being built up by the broken circuit ends falling upon some conductor.

(6) No alternating current with a higher electromotive force than 300 volts shall be used.

I have also read the communication of Mr. Brown accompanying the proposed amendments. It has been my privilege to attend a large proportion of the meetings of the Board, and I believe I thoroughly understand its desires in the premises, which are in the main, to bring about a reform in the existing condition of electrical conductors in this city, without interfering with the business interests of their owners or depriving our citizens of the many benefits accruing from the various systems which depend upon electricity for their successful operation.

One of the greatest difficulties encountered in the proper regulation of electrical service prevails in other branches of modern industry, where the danger to life is outweighed by the desire to increase financial gain. These facts are so generally recognized that I refer to them merely as a reason why it is proper that every precaution which science can devise should be utilized for the protection of human life. The rules in question appear to have been framed with this object in view, and so far as they are confined to this praiseworthy object, they meet with my unqualified approval.

It is now the generally accepted opinion among scientific investigators, many of whom have had ample experience upon which to base their reasoning, that there is a wide range of difference between various persons as to their power of enduring the effect of an electric shock. The same person may also be much more susceptible to its influence under certain conditions of the body, as, for instance, when the skin is moist from any cause. A person unaccustomed to the peculiar sensations caused by the passage through his system of an electric current, if of a sensitive nature may suffer from fright. Indeed the mere spectacle of a thunderstorm, where the chances of personal injuries from lightning are infinitesimal, may produce serious results. It will therefore be understood that it is extremely difficult, if not impossible, to fix upon an arbitrary standard which an electric current must not be permitted to exceed; for the reason that many useful classes of service may thus be entirely prohibited without any substantial reason. All forms of electricity as used in the various systems with which we are familiar, are entirely controllable, with the exercise of such skill and experience as now exist. No form of current is used which, with the exercise of proper precautions, cannot be confined to its legitimate path, and it is in this direction that it appears to me our efforts should be directed. When, with the introduction of every known precaution, it is found impossible to so confine an electric current to its proper channel, it will be time enough to prohibit it by statute. The very fact that many companies now doing business have *not* exercised that precaution which the interests of the public demand is the reason for the existence of the Board of Electrical Control. In view of the prevailing opinion upon the importance of so constructing and operating an electrical plant of any description, it appears to me that any company or individual proposing to establish an industry of this character, at this date, must be well aware of the importance of complying with such rules as are established by the proper authorities acting in the interests of the public.

The pith of the line of policy to be pursued, in my opinion, therefore, would be not to fix upon any particular number of lamps to be operated on one circuit, or any standard of voltage which must not be exceeded, but rather to insist on such methods of construction and the use of such material, that the current will be confined to its designated conductor. This implies the use of a conductor of ample size for the current to be used, and properly insulated at all points, the insulation resistance increasing in a proper ratio to the increase of voltage.

If we aim constantly in this direction, I believe we shall eventually attain the end we all have in view, which is the greatest possible extension of the benefits to be derived from the more general use of electrical devices, without danger either to life or property, even when the various fixtures and appurtenances are necessarily within the reach of persons not familiar by training with the mysterious dangers which are supposed to lurk in every electric wire.

I would, therefore, respectfully suggest that the first and the last of the proposed rules be stricken out, and that the second rule be more fully elaborated.

In view of the fact that with the best possible methods of construction accidents are liable to happen, rendering an otherwise perfect system defective, I should recommend the adoption of the precautionary rules numbers 3, 4 and 5, provided there be no existing practical reasons why they should not be enforced, as I am not in favor of the adoption of any regulations of such a character that they must necessarily remain a dead letter.

Yours very truly,

RALPH W. POPE.

STEVENS INSTITUTE OF TECHNOLOGY.
HOBOKEN, N. J., July 16, 1888.

THE BOARD OF ELECTRICAL CONTROL.

Gentlemen:—In response to a letter from Mr. Theodore Moss, dated June 20, inviting me to express my views on the subject discussed by Mr. H. P. Brown in a letter to the *Evening Post* bearing date June 5th, 1888, I would say that I quite agree with Mr. Brown in his opinion that in all cases mentioned by him in which death has been caused by coming in contact with electric wires the accidents would have occurred, just the same, if the wires had been buried underground, or, to use his own words, "I know that burying the wires would not remedy the trouble." I would, however, go further than this and say that in the instances he cites and in all others known to me, the accident which occurred would have been more likely to occur or more certainly fatal if the wires had been buried underground in any arrangement which has as yet been provided for that purpose, and this chiefly for the following reasons :—

The buried wires, as experience has abundantly shown, are in constant danger of making earth connections which render a contact with only one point fatal where it would be otherwise harmless. Even the Edison wires in New York are frequently being torn up to repair injuries due to loss of insulation, notwithstanding their very low electromotive force, of but 110 volts, as any one can see who has occasion to go about the streets traversed by the Edison conductors down town.

When currents of 20 times this "electric pressure," as it has been aptly called, are used this tendency to rupture the insulation is proportionately increased and has proved practically fatal to any commercial success in using such currents through underground conductors.

Those persons who have been killed by touching lamps or single wires have been killed only because there was some earth connection already established elsewhere on the circuit.

Again in the instances where employés of the electric companies have been killed while employed in connecting or otherwise working with wires carrying currents, it is manifest to any one that the danger would be greatly enhanced if their work was to be done in dark and narrow "man-holes" in place of in broad daylight and in free space.

The cry of the public as represented by the daily press, to put the wires underground as a remedy to all dangers and difficulties, is not an intelligent cry, but, on the contrary, is the result of ignorance and misdirected prejudice.

In the next place Mr. Brown points out at some length the difference between a continuous uniform and a pulsating or alternating current, but in this connection I think that he has rather mixed up and confused several different things.

The intense effects produced by an induction coil such as is used for giving shocks and in medical treatment, is not the result of its interrupted character, but of the peculiar arrangement of magnetic core and coils of wire, by which the electromotive force of the interrupted secondary current produced is raised to a point fully equal to that of the longest circuit ever employed in an arc light system.

In other words, the *electric pressure* obtained in a medical coil is fully equal to that in an arc light circuit carrying 50 lights. It is also alternating, and therefore, as far as their conditions are concerned, should be certainly fatal. Such, however, as every one knows, is not the case. I myself once received the discharge of such a coil capable of giving sparks 21 *inches long*, and therefore equal in electric pressure to hundreds of arc light dynamos united for that purpose, and the sensation was no worse than the shock from a Leyden jar of moderate size.

It is manifest, therefore, that the interrupted or alternating character of the current even when combined with the highest electric pressure, is not its essentially fatal condition.

The actual facts seem to be these, as far as we can gather from the fortunately very limited number of accidents, fatal or otherwise, which have occurred.

There are two ways in which the electric current can derange the living structure,—1, by mechanical and chemical injury to the organic structure; 2, by nervous exhaustion or nervous shock.

The first of these requires the passage of a considerable volume of current with enough electromotive force to carry it through the resistance of the body. These conditions are fulfilled by a continuous or uniform current of high electromotive force, and are not found in the same degree in an alternating or interrupted current.

The second method of injury, or that by nervous shock, requires chiefly the interruption or reversal of the current, but this nervous influence only becomes dangerous when long continued or combined with the other influence of large current volume.

Experience, however, shows that the interrupted current loses as much in the direction of fatal effect from organic destruction as it gains from its superior nerve exhausting power, so that quite as many have escaped without fatal consequences from an alternating current as from a continuous one. Either may be fatal, but neither has any known superiority over the other in this respect, and there is certainly nothing in the results of experience or observation so far which would warrant us in requiring less precaution in the use of one sort of current as compared with the other, or in excluding one where the other was admitted.

Mr. Brown states, as of his own knowledge, "scores killed and maimed by the pulsating currents." In regard to this I can only say that I have no such information either direct or derived and would be very much interested in investigating these scores of cases, if Mr. Brown would give some specific reference to them.

I quite agree with Mr. Brown as to the imperfections of the underwriter's wire. This wire was passed or allowed by the underwriters many years since, when it was the best and only wire available for the purpose; but they have since "approved" many other wires with superior insulation which have just as much claim to be called "underwriter's wire" as the first and inferior kind.

What Mr. Brown says about the universal condemnation of the alternating system by electricians of high standing and disinterested, must be founded upon a very limited knowledge of the subject. The only authority he cites is that of Siemens and Halske, who are known to everybody as manufacturers of, and dealers in, dynamos, electric lamps, etc., patented by themselves, and authors of a pamphlet or trades circular attacking the rival system of electric lighting by secondary currents with so manifest a bias, as to deprive what they say of any weight whatever. I can hardly believe that Mr. Brown can have seen this publication, but must speak from some incorrect report of its contents.

Without taking up more of your time, however, with a discussion of Mr. Brown's preamble, I will at once pass to his proposed rule.

Rule 1, proposes limiting arc circuits to 50 or 60 lamps each. This would be a very unscientific and unfair method, as it would allow some companies to run circuits of twice the electromotive force or pressure of others. Thus 50 Brush lamps would require an electromotive force of 2,500 volts, while 50 U. S. Electric Lighting Co's lamps would require but 1,500 volts. The rule should be founded on some accurate standard of measurement, and be not like the weight standards of the early Dutch settlers described in Knickerbocker.

Rule 2, providing for insulation of wires as stated, is utterly indefinite and meaningless. Under it a naked copper wire might comply with the requirements and the Atlantic cable might fail to do both, within reasonable constructions of the rule as stated.

Rule 3, providing for a cross-circuit of high resistance near the dynamos, is also indefinite and unnecessary, but would do no harm.

Rules 4 and 5, providing automatic means of shutting off dynamos on the grounding or breaking of their circuits, are good; but are already carried out in most electric lighting systems.

Rule 6, excluding the use of alternating currents of high electromotive force, is unwarranted and absurd.

If more time was at my disposal I could enlighten your commission on many other points connected with this subject, but believe that I have said enough already to discharge my duty as a good citizen in a matter in which I have no direct concern.

Very truly yours, HENRY MORTON,
President.

PITTSBURGH, PA., July 7, 1888.

C H. JACKSON, ESQ.,
Pres. Safety Electric Light and Power Co.,
New York city.

Dear Sir:—In reference to the questions which you have brought up for my consideration regarding the safety and reliability of the alternating current system of distribution, I would say first, in regard to the matter of personal safety, that I regard the alternating current less dangerous to human life than the direct current, for several reasons. In the first place, I am well acquainted with a number of electricians and men connected with electric lighting work who have received, through their bodies, a current due to alternating difference of potential, varying between 1,000 and 2,000 volts. I have myself received 1,000 volts without even temporary inconvenience, and in the case of one of the electricians connected with our interests, a shock of something greater than 2,000 volts was received without fatal results. During my experience with direct current dynamos I have frequently received a shock due to the extra current from the field of a machine suddenly opened, and I have no hesitation in saying that the shocks I have received in this way from machines designed to produce only 100 volts electromotive force, were much more severe than those I have received by direct contact with the primary circuit of a Westinghouse 1,000 volt dynamo, when its field was charged to the full normal amount.

It is simply out of the question to produce any practicable extra current in the armature circuit of an alternating current machine from the opening of the field, particularly when the machines are separately excited, and this is for the reason that there is no connection between the armature and the field circuits, and the effect of suddenly interrupting the field current is only to interrupt the current in the armature without producing a sudden flash of high electromotive force, which inevitably follows from the interruption of the field of a direct current machine. The construction of the alternating current dynamo is such that, although the current changes its direction 200 or 300 times a second, yet it is prevented by the very nature of the machine from raising any potential beyond a certain limit determined by the design of the machine. In the direct current machine, on the contrary, there are no such restrictions, and I feel quite safe in saying that the discharge from the field of a direct current machine of 100 volts, normal potential, may be capable of rising to fully 100 volts when the field circuit is suddenly interrupted. I do not give this as a matter of opinion solely, but as a matter of actual experience and conviction. This quality of the direct current machine has often rendered it necessary, in my own experience, to interpose a number of incandescent lamps, say five or six, across the breaking points of the field rheostat, so that on the interruption of the field circuit the arc formed across those contacts would be prevented to some extent, the result of this arrangement is that half a dozen or more lamps, connected in series, would be flashed up to their full brilliancy by the so-called 100 volt dynamo; whereas, under normal conditions, it would require as many 100 volts as there are lamps to produce a similar condition. There is a very convincing reason for the small danger due to alternating current shocks to the human body as compared to those received from the direct current; namely, the fact that the conducting fluids are more or less decomposed or electrolyzed by the passage of the direct current, while it is well understood that such an effect is not produced by the alternating current. It is therefore evident that the passage of the direct current through the human body, for even a moderate length of time, may be sufficient to so decompose the fluids and tissues of the vital parts as to produce fatal results very quickly; whereas a current of the same quantity of rapidly alternating potential may produce only a shock to the nerves without any organic change, consequently without permanent or even serious danger.

This statement is well borne up by the fact that it is impossible to measure correctly the resistance of the human body by means of a direct current, as the resistance changes continually while the measurement is in progress, even where the contacts are preserved carefully, and where the utmost care is exercised to produce accurate results. The decomposition of the fluids thoroughly explains this, since it is a well-known fact that in all cases of electrolytic action the resistance is never the same for any considerable period. With the alternating current system it is possible to obtain definitely the resistance of the human body with contacts of a given nature; consequently, the effects of the alternating current can be determined and counted upon much more easily than the direct.

Laying aside the question of the relative danger of the alternating and direct current, it is a matter of every-day experience that a 50 or 100 alternating current is perfectly safe; and it is perfectly possible and easy to confine the difference of potential entering a house from the street circuit.

The insulation on the converters as now employed, and as they have been in use since the commercial operation of the alternating current system is so perfect that among several thousand converters now in use under the patents of the Westinghouse company, I have yet to learn of a single instance in which any connection has been discovered between the primary and secondary wires. These converters have been in use under almost every conceivable condition of location, and surrounding conditions, and a large number of them being in use in the open air, and up to the present time no accident to life or property has been recorded. As a matter of fact the converter is a safeguard to the consumer, protecting him from all dangerous currents likely to traverse his wires, namely that from lightning. Where the circuit is continuous from the pole line to the lamps an excellent conductor is provided for the discharge of the lightning flash wherever the ground insulation happens to be the weakest, and for this reason we hear of lightning entering buildings and destroying property to a greater or less extent, particularly at the central stations where the greatest number of conducting wires

enter, and where masses of metal, either more or less connected, are apt to form the weakest points in the system of insulation. Where the converter is interposed between the line wires and the circuit likely to be handled by the consumer, a safeguard is provided, the effect of which on the passage of a lightning discharge is simply to work an injury on the converter itself, separating it from the surface wires, and temporarily interrupting the supply of current. In the experience of our company a number of cases have occurred in which lightning has almost totally destroyed the converters, and the result has been in every case to disable the primary coil, cutting it out of action and immediately freeing this circuit from the converter, owing to the increased current passing through the primary coil under these conditions. It will be impossible for the converter to remain in circuit when sufficiently injured by lightning to render insulation between the primary and secondary circuits insecure. Under all other conditions than the burning out of the converter by lightning or destruction by fire, the nature of the insulation between the primary and secondary circuit is so perfect that it is almost impossible that any connection should occur between them, since the insulation is made up of several distinct and perfect envelopes for the wire. These insulations are as waterproof as it is possible to produce them, when uninjured by a mechanical abrasion, and from the latter the coils are thoroughly protected by an enclosure in the iron casting with which each converter is provided. The insulation is not only carefully carried out from the primary to the secondary coil, but between each coil and the iron plates which form the surrounding field; so that the insulation measured from one coil to the other through the iron is in reality double the insulation from coil to coil.

In regard to the question that has been raised as to the reliability of the safety fuses, I would simply call attention to the well-known fact that the fuses of moderate size are much more quick and reliable in their action than the large fuses. The current in our system traverses four pairs of fuses between the dynamo and the lamp, all of which fuses are of moderate size, even where 2,000 or 3,000 lights are distributed over the same primary circuit. In case of accident by lightning or otherwise, which would disable the converter, the usual effect is to immediately burn out the primary safety fuses of the converter, but, should this fail for any reason, the passage of any abnormal current through the secondary fuses would cut them out, and, failing in this, they would have still between the converters and the lamps the local fuses, which are of still smaller capacity, and therefore readily discharged. I might amplify on these matters to a very considerable extent, but have confined myself to explaining the material matters in which our system has safeguards, which make it absolutely reliable to life and property. In conclusion, I might state emphatically that the converter whether for underground or overhead use, and particularly in the latter event, is an element of safety of a very appreciable amount against danger from currents of higher tension than is used in alternating, which may, by any event, be brought into contact with the primary wires of this system.

Yours respectfully,

O. B. SHALLENBERGER.

WESTINGHOUSE ELECTRIC CO.,
PITTSBURGH, Pa., July 14, 1888.

Mr. C. H. JACKSON,
President, Safety Light, Heat and Power Co.,
New York city.

Dear Sir:—I am in receipt of your favor enclosing a clipping from *New York Evening Post*, which clipping simply is an attack upon the alternating current system, signed by Harold P. Brown.

I have carefully read this article, and beg to call your attention to the following facts and observations in connection with the same. About twenty months ago the Westinghouse Electric Co. began the commercial introduction, on a large scale, of the alternating system of electric lighting. The advantages of this system immediately appealed to the wants and experience of parties already engaged in central station lighting, and of those who, up to that time, had been seriously considering going into the business but had not actually embarked in the enterprise, in consequence of the absence of any system which would fill all the requirements in a commercially successful manner. The first plant introduced by this company on the alternating system in this country was started at Buffalo, N. Y., on November 30, 1886. After that, other plants were rapidly sold and put in operation, until at the date of this letter the Westinghouse Electric Co., and its licensee, the Thomson-Houston Electric Co., have sold in Canada and the United States a total of 127 stations using the alternating system, and of which 98 stations are in operation at the present time, the remainder being under construction. Among these 127 stations there are several which, to the best of my knowledge and belief, are the largest incandescent lighting stations in the world. Notably the Virgin Alley station in Pittsburgh, having a generating capacity of 15,500 16-c. p. lamps, and which, together with its sub-stations operated by the same company (the Alleghany County Light Co.) in Alleghany City and east end Pittsburgh, make a total of 25,800 16-c. p. lamps on the alternating current system in daily use in the cities of Pittsburgh and Alleghany, being a larger number of incandescent lights than are served at the present time from central stations in any city in the United States. The plant of the Denver Light, Heat and Power Co., Denver, Col., which was put in operation in December, 1887, is now supplying over 8,000 16-c. p. lamps. The central station at Richmond, Va., which originally started with 650 16-c. p. lamps and subsequently increased to 2,600 16-c. p. lamps, has now added another increase, giving it a total generating capacity of 7,600 16-c. p. lamps on the alternating system. The station at New Orleans, originally operated by the Southwestern Brush Electric Light and Power Co., but now the property of the Consolidated Electric Light Co., has over 7,500 16-c. p. lamps in successful operation. At Baltimore, Md., the Brush Electric Light Co., of Baltimore city, has just started a station of 5,000 lights. The Richmond Light, Heat and Power Co., of Staten Island, New York, has a station which at present is operating over 4,000 16-c. p. lamps.

Of the stations which are in operation at the present writing, and all of which have been sold and installed since November 30, 1886, 34 have increased their plants since putting them in operation.

You will readily understand, upon a consideration of the foregoing, the enormous amount of work which has devolved upon the officials, electricians and engineers of the Westinghouse Electric Co. in developing and introducing this enormous business within so short a time, and that it has been considered inexpedient, heretofore, to take any notice of, or make any reply to, the criticisms and attacks of some of the opposition electric lighting companies, which have developed recently in a method of attack which has been more unmanly, discreditable and untruthful than any competition which has ever come to my knowledge. The article of Mr. Harold P. Brown, referred to, is a fair sample of the class of attack referred to. I have neither the time nor the inclination to answer in detail the charges brought forward by Mr. Brown, nor, indeed, do I consider it at all necessary, as in spite of this and similar attacks above mentioned, the business of the company is steadily increasing, and the only results produced by such articles are a certain amount of annoyance.

However, I would say, briefly, and all of which we are prepared to have substantiated by an intelligent and thorough test and examination of our system by any competent engineer or engineers:—

In the first place, an alternating current is far less dangerous as to fire or life risks than a current of what is known as the continuous or direct current type. This is a matter which can be readily proved by breaking two currents, one of the alternating and the other the direct, by the same switch. In the case of the direct current a long and vicious spark will occur, and which, if the current is of sufficient volume, will probably melt the edges of the switch. With the alternating current a spark barely perceptible, and with none of the heating and melting defects, will be observed by the same operation. As to life risks, it has been demonstrated to our entire satisfaction and the entire satisfaction of people who have given the subject an intelligent investigation, that the effects of currents of the two systems upon animal life are very unequal, and the effect of the alternating current is immensely less, both as to burning and possible death, than the direct current of the same volume and pressure as explained by Mr. Shallenberger.

Of the 98 central stations of the Westinghouse Electric Co. now in operation, and all using the alternating system, we have yet to receive knowledge of a single case of fire of any description from the use of our system. Of the 125 central stations of the leading direct current company there are numerous cases of fire, in three of which cases the central station building itself was entirely destroyed, the most recent being the destruction of the Boston station; while among the almost innumerable fires caused by this system, among the users, may be mentioned the total destruction of a large theater at Philadelphia, which fire was directly caused by the direct current system of the leading direct current electric light company of the country. Regarding the alleged life risks by the use of the alternating current system, I would say that the potential, or pressure, or electromotive force used on the primary lines with the system of this company is 1,000 volts, as against a pressure on the three-wire, direct current system of 200 volts. Greater care in running these primary wires, either overhead or underground, is required than would be the case if a lower pressure were used, and it is possible under certain contingencies for a person through carelessness to become so connected with these primary wires as to receive a shock which may possibly prove fatal; but this risk is reduced to a minimum. It is a common matter for the three-wire central station companies, using the direct current system, to run a special wire usually for street lighting purposes, carrying a potential on the direct current system of 1,000 volts, and which, as explained above, is certainly more dangerous in every way than 1,000 volts

of the ordinary system. It must be distinctly borne in mind, however, that the street wires carrying the primary current of the alternating system are never carried into the houses, and that the current which goes into the buildings and houses to feed the incandescent lamps has an E. M. F. of 50 or 100 volts as against an E. M. F. of 200 on the three-wire system; and I further state, beyond any possibility of contradiction, that it is utterly impossible by the construction of our apparatus, for a high tension current used in the primary wires to pass the converters and enter the houses. An intelligent examination of the construction of our apparatus will prove this beyond any question of doubt. As to the alleged impossibility of the operation of our system on an underground circuit, I have only to say that any statement of this nature is absolutely and entirely false. The company using our system in Denver, Col., and which has been referred to previously in this letter, has been employing our underground system very successfully with a distributing capacity of over 12,000 16-c. p. lamps. At Springfield, Mass., we have an underground system in successful operation, with a distributing capacity of 2,100 16-c. p. lamps. At the Keystone Light and Power Co., in Philadelphia, they are distributing over 2,600 16-c. p. lights through an underground system.

We are prepared at any time to furnish plans or take contracts for the introduction of our system by underground wires, and to guarantee its successful performance under all circumstances, so long as our plans and specifications are adhered to, and the very successful operation of the three underground stations mentioned, certainly is more assuring in this direction than the very unsatisfactory performance of the underground three-wire system, which underground system has been attended with continual trouble, and has required the most careful nursing from the time it was started up to the present moment. As, for instance, at Detroit, Mich.; Columbus, O.; Chicago, Ill.; Philadelphia, Pa., not to mention others. Whenever local companies are willing to incur the extra investment required for putting the wires underground, we are also prepared to furnish them the system, with sufficient guarantees for its successful performance.

The dismal commercial results so far achieved by the majority of central stations using the three-wire system, owing to the fact that the low tension which they are required to use with that system prevents the possibility of their covering a sufficient territory to ensure a permanently successful business, certainly warrants the expenditure by local companies of a little more cost in insulation and care in construction of their lines to enable them to use such a system as the Westinghouse Electric Co. has so successfully introduced, and by the use of which system any local company can permanently occupy the field instead of being in a position where it is continually harassed, and having its business cut into by other companies coming into the same field while it is itself unable to strike out and occupy new territory.

The idea of locating a central station in the heart of the most thickly populated section of a city or town, as, for instance, the three-wire system in Philadelphia, paying enormous sums for the haulage of coal and ashes and even for the use of water for the boilers, when by the use of the alternating system of the Westinghouse Electric Co. the same stations could be located on some river bank or contiguous to a railroad, thus avoiding all expense of haulage and for water, is surely one which does not appeal to the common sense and experience of the people who are acquainted with engineering enterprises.

In closing, I would call your attention particularly to what is probably the most recent attack against this company, and a consideration of which, together with the accompanying facts as put forth in printed circular enclosed, will, I think, make clear to you the utterly irresponsible nature of the parties carrying on such a campaign against us. I refer to the enclosed circular which has come into our hands marked "confidential to agents," and printed over the signature of Ed. H. Johnson, president of the Edison Electric Light Co.; this company, as you are aware, using what is known as a three-wire low tension system. It is certainly manifest from this that the desperation of the opposition companies has reached a point where even a regard to their own interests is thrown aside, and the only explanation which I can apply to the issuance of the confidential circular in question is to consider it as a last effort on their part.

The previous circulars and pamphlets which have been issued have been all of the same nature, and are all susceptible of exactly as sweeping a reply as this; but, as explained previously, we have felt no injury resulting from the circulation of such literature, and have neither the time nor inclination to reply to it.

Trusting that this rather lengthy letter has, at least in a measure, replied to your inquiries, and again stating that we are ready at all times to invite the intelligent examination of our system by parties who will do so in a fair-minded and straightforward way, and in such manner as was done by the Society of Gas-lighting, of which Mr. Eugene Vanderpoel, president Newark Gas Light Co., Newark, N. J., is chairman.—I remain,

Yours very truly,

H. M. BYLLESBY,

Vice-President and General Manager.

Mr. Wm. H. Browne, treasurer and manager of the Safety Electric Light and Power Co., of New York, who handed in the letters of Mr. Shallenberger and Mr. Byllesby, also presented a communication from himself of much the same purpose and effect as the letters of those gentlemen. Mr. Brown's letter was read.

An able letter from Mr. Seymour G. Smith, president of the East River Electric Light Co., was next read to the board, from which the following extracts are taken :—

"Mr. Brown has further attempted in his article to draw a distinction between what he terms the 'open circuit armature' and the 'closed circuit armature' in regard to the nature of the current, the closed circuit armature being commended because it is supposed to produce a perfectly smooth current, while the open circuit armature is condemned on the ground that it produces a 'pulsating' current, and that the current produced by it is the same as that of a medical battery having an induction coil and a circuit breaker in the primary. There is no similarity, in fact, whatever between the currents produced by these two devices.

"Your board's expert will tell you that an 'open circuit' armature never breaks the circuit for the lamps or other devices, and that there cannot therefore be a current of the same nature as that produced in an induction coil where the primary circuit is absolutely broken. The current of the 'open circuit' armature, it is true, pulsates slightly, as does also that of the 'closed circuit' armature, but the extent of each pulsation is not in either case the whole pulsation of any one part of the armature; but a tendency to pulsation is counteracted by the fact that while the current in one coil is rising or falling, as the case may be, the current in other coils connected at the same time to the circuit is rising or falling, and the resultant effect is a current very nearly uniform. In some machines the tendency to pulsation is further counteracted by what is known as electrical or magnetic inertia of the armature which causes a prolongation of the currents, so that the lapping of the currents upon one another is extended and the sharpness of pulsation reduced.

"There is not, as Mr. Brown would have the public understand, the difference in danger which he assumes between the use of a 'closed circuit armature' and an 'open circuit armature.' The records of deaths do not support his views; and if there be any difference in the number of casualties, we believe that it will be found to be due to the difference in the electromotive force of the machine employed, or to the predominance of the systems using the 'open circuit armature.' The closed circuit armature, as at present constructed, does not lend itself so readily to the production of high electromotive force, and the running of a large number of lamps in series; at any rate, such has been the history of the development of the art. The open circuit machines have been practically constructed so as to run more lamps in series, while the companies using the closed circuit armatures have found difficulty in making successful and reliable machines which would run arc lights in series up to the number which it is possible to employ with the machines of their rivals. There seems to be no doubt that there is a limit of electromotive force and quantity of electric current which can be passed through the human system without producing fatal effects. Just what that limit is with any particular kind of current is not established, and it certainly is not established that any particular kind of current is necessarily more fatal than another. No conclusion on this subject can be drawn from the effects produced by an ordinary induction coil, the nature of whose secondary current differs so greatly from that of arc lighting circuits. If electromotive force or tension were the quality alone which determined the injurious effects of an electric shock, the ordinary induction coil should be far more fatal in its effects than the ordinary electric light current of even (3,000) volts, inasmuch as the electromotive force of the current from the secondary is, as is well known to electricians, enormously greater. The voltage of the alternating current which would be used in practice is like that of the present arc light currents, far below that of a medical induction coil, and there is even reason for supposing that the alternation of current would tend to prevent destructive effects, each current tending to undo the work of its predecessor.

"The rule as to the quality of insulation to be used for out-door arc circuits we see no objection to, and this company, in fact, takes particular care to run circuits of the quality demanded by the rule.

"The sixth rule, with regard to the electromotive force permissible in systems employing alternating currents, is simply prohibitory upon the use of such systems. There is not, even under the most unfavorable view which can be legitimately taken, such a difference in the danger from the use of alternating currents and continuous or ordinary arc light currents, as to warrant the requirement proposed under these rules.

"The first of the suggested rules allows an electromotive force of from 2,500 to 3,000 volts in the case of ordinary arc light currents. The last rule practically allows but a tenth of that voltage in the case of alternating currents.

"It is no more than right that your board should take notice of

the fact that there has been a systematized attack made upon the alternating system by its business rivals, and for that reason alone any objections to the systems should be received without hesitation. The practical commercial advantages of the alternating system are such that it cannot be suppressed. The progress of development of the art of electricity is unquestionably in the line of alternating currents, and for reasons which all electricians will recognize.

"Recent inventions have made it practicable too perate electric motors from alternating currents without the use of commutating or circuit changing devices of any nature whatever in the motors. The importance of this attainment can hardly be over-estimated. It enlarges at once the field of electricity as a distributor of motive power, a fact which certainly should not be overlooked in a city like New York where so many and large manufacturing interests are located."

This company believes that alternating current electric motors without commutators or circuit changers of any description are a practical thing, and the use of such motors on an alternating current system forms a part of the contemplated business of this company, with reference to which it was organized and obtained its charter. Such business must form a large and profitable source of income to every company which shall either purchase or acquire the right to use motors of this description.

The following affidavit, made by W. L. Wright, was presented:

AFFIDAVIT OF W. L. WRIGHT.

PHILADELPHIA, City and County, } ss.

William L. Wright, being duly sworn according to law, deposes and says:—"On the 5th of August, 1887, I was in the employ of the Keystone Light and Power Co. in Philadelphia, Pa., and had occasion to do work in the cellar of the building at Eighth and Chestnut streets, Philadelphia, occupied by Castor & Co. The electric wires in the cellar upon which I went to work had been, until a few days before, used for a 200 volt three-wire direct current system, and a socket had been attached to them by means of a long flexible cord to give a temporary light in the cellar. The wiring had then been changed and connected to the 1,000 alternating current, and, forgetting that this current would be on the socket, I took hold of the socket while standing on the wet ground, when I received a shock which threw me on my face with my hand underneath me, and still grasping the socket.

"I have been accustomed to handling high tension currents, and knew that I was in danger, but was not able to call out to the man who was with me. I retained consciousness for some time, but was gradually rendered insensible. When I came to my senses I was sitting in the cellar held up by two of the men. In the meantime an ambulance had been called, but I refused to go in it, as I did not feel in any way injured except that my hand had been badly burned. I went down to the electric light station and waited there for fifteen or twenty minutes to receive my money, it being pay-day, and then went home. At the urgent request of the officers of the company I went to see Dr. Horace Williams, 1717 Pine street, Philadelphia, who dressed the burns on my hand. These burns healed very slowly; but I have not felt in any way any of the after effects from this shock, such as are usually felt from high tension direct current machines.

"I am familiar with arc light currents, and have received in my business many severe shocks, and I feel sure that had I received this kind of a shock from a direct current machine of any of the ordinary types * * * * * * it would have been fatal.

"I have worked with the alternating current both on the primary or high tension wire and the secondary or low tension wires, and am familiar with the placing of converters in different situations throughout buildings, and when placed, as they are placed in Philadelphia, under a proper set of rules such as the Board of Fire Underwriters have approved in Philadelphia, I do not see how any one can be hurt on the secondary wires, as in case of any accident the safety fuses in the high tension wires melt out immediately, and I think that the high tension wires, when properly boxed in, are a great deal safer than arc light wires can possibly be. And further saith not."

(Signed) W. L. WRIGHT.

Sworn and subscribed to, before me this Seventh day of July, A. D. 1888. }

THOMAS D. SIMPSON,
Notary Public.

Other affidavits to the same effect were presented, signed by John Klepper, Benjamin Acker, Albert Schmid, George Fulton, John Schwartz and C. J. Thompson.

At the request of the board, Mr. T. Carpenter Smith explained the underground system, as used by the Westinghouse company in Pittburgh, and in reply to an enquiry by commissioner Gibbens, said that he considered the subways in New York superior to those used elsewhere in this country. He then dissected a converter for examination by the board, showing that the statements made by Mr. Brown as to its insufficient insulation were erroneous. President Hess then called for the opinion of Mr. H. P. Brown, or any other person who desired to appear and argue against the introduction of the alternating system in New York city, but there being no person present who desired a hearing, the meeting was declared adjourned, subject to the call of the chair.

MR. BROWN'S REJOINDER.

ELECTRICAL DOG KILLING.

At the Physical Laboratory of Columbia College there were assembled on Monday, July 30th, an audience of about seventy-five, upon the invitation of Harold P. Brown, who had undertaken to exhibit the fatal effect of a high tension alternating as compared with a high tension continuous current. Among the gentlemen present were E. A. Leslie, Schuyler S. Wheeler, Theodore Moss, Daniel L. Gibbens, T. Carpenter Smith, C. H. Jackson, W. H. Browne, Jno. A. Howell, E. T. Birdsall, Joseph Wetzler, P. H. Van der Weyde, Wm. Brophy, D. Killicutt and Mr. Curtis.

No intimation of the character of the exhibition had been given, and it is safe to assume that had the revolting nature of the experiments been known the attendance would have been very slim.

A wooden cage, with heavy copper wire interlaced among the bars, had been prepared for the reception of a dog, which was to be tortured by a continuous current and killed by the alternating, in order to demonstrate the dangerous character of the latter.

The dog was dragged into the room and incarcerated before the audience. As he was not yellow there appeared to be considerable sympathy manifested for him, and consequently Mr. Brown felt it to be his duty to announce that he was in reality a desperate cur, and had already bitten two men.

The dog weighed 76 pounds, and although his character had been villified his mild appearance suggested that there might be another side to this story if a friend had been present to state it. Mr. Brown then read a lengthy paper, in which he laid particular stress upon the fact that he was not in the employ of any electrical company, but that he had been actuated in this matter by a desire to prevent loss of life arising from the indiscriminate use of high tension currents.

In order to assure the audience that the experiments would be fairly conducted, he requested A. E. Kennelly, of Edison's laboratory, Dr. Schuyler S. Wheeler, of the Board of Electrical Control, and T. Carpenter Smith, to assist in the demonstration.

The connections with the dog were made to his right fore leg and left hind leg by wrapping them with wet waste, bound on with No. 20 bare copper wire. The resistance of the dog and his connections was measured under the supervision of Dr. Wheeler, and announced to be 15,300 ohms. The strength of current was two-tenths of an ampere. A relay had been introduced into the circuit, so that the extra current from the discharge of the field magnet would not reach the subject. This is the device recommended by Mr. Brown, and he stated that without its use 500 volts from the continuous current machine would cause death. Various tests were made with an electromotive force of 300, 400, 500, 700 and, finally 1,000 volts from an Edison "municipal" dynamo, the effects of which upon the doomed animal were heartrending in the extreme. As the voltage was raised, and the dog, in his frantic efforts to escape, succeeded in forcing his head through the meshes of the wire enclosure, many of the spectators left the room, unable to endure the revolting exhibition. By the continuous application of high tension currents the resistance of the dog was reduced to 3,500 and finally to 2,100 ohms, and his vitality had been so reduced that it was a question with the audience whether he was dead or alive.

Mr. Brown announced that he could produce a still higher voltage, but there was no desire to witness the further torturing even of a vicious dog, and the chief executioner sarcastically stated that he would then introduce the alternating current in order to make the victim "feel better," such having been stated by advocates of the converter system as the effect of the current used by them.

A gentleman in the audience here protested, in the name of humanity, that this particular dog be killed at once. As Mr. Brown claims to be a voluntary representative of the cause of humanity he acquiesced, and an electromotive force of 330 volts ended the death struggles of the tortured victim. The ampere measurement of the alternating current could not be determined, therefore the whole exhibition proved nothing beyond the fact that a continuous current of 1,000 volts and $\frac{2}{10}$ amperes while it will not kill a healthy dog, is far less satisfactory to him than an alternating current of 330 volts electromotive force and unknown volume.

A protest was made by a reporter of the daily *World* against a continuance of the inhuman performance, and an agent of the Society for the Prevention of Cruelty to Animals intervened at once, and stated that while experiments of this nature, conducted

by colleges and institutions for the benefit of science, might be permitted, he should prohibit their continuance in the interests of rival inventors.

There was a general feeling of relief at this humane interference. Dr. Frederick Peterson, who has assisted Mr. Brown in his investigations, then read a paper upon the effects of electric currents upon living animals, which closed an exhibition, in comparison with which a Spanish bull-fight is a moral and innocent spectacle.

THE EDISON LAMP PATENT ADJUDGED INVALID IN ENGLAND.

Mr. Justice Kay delivered judgment July 19th. The trial occupied the time of the Court for no less than 21 days, the Lordship reserving judgment at the conclusion of the arguments. The action was by the plaintiff company to restrain an alleged infringement of their patents by the defendants, Mr. William Holland, the manager of the Albert Palace, Battersea (where incandescent lamps had been used which, it was said, were substantially the same as those protected by the plaintiffs' patents), the Jablochkoff and General Electricity Co. (Limited), who had supplied the lamps used at the palace, and the Anglo-American Brush Electric Light Corporation (Limited), who were the manufacturers of them, and had entered into an agreement with the Jablochkoff company to indemnify them against the litigation. The patents upon which the plaintiffs sued are the same as those they succeeded in maintaining in the Court of Appeal last year, in two actions by them against Messrs. Woodhouse and Rawson—namely, the Edison patent, No. 4,576, of 1879, for the incandescent lamp, and the Chesebrough patent, No. 4,874, of 1878, for a mode of making uniform the carbon filament or thread which forms the light giving portion of the lamp. The cases against Messrs Woodhouse and Rawson will be found reported in *The Times* of May 23, 1886, and February 13, 1887; also in *The Times* Law Reports, vol. 2, pp. 654–656; and vol. 3, pp. 327, 367. During the delivery of Mr. Justice Kay's judgment, which occupied nearly an hour and a quarter, the Court was crowded to excess with persons of eminence in the scientific world, besides the general public.

Mr. Justice Kay said—The plaintiffs sue the defendants for infringing two letters patent; one Edison's patent, No. 4,576, of November 10, 1879; the other Chesebrough's patent, No. 4,874, of 1878, amended by disclaimer dated the 12th of November, 1884. Both patents relate to electric incandescent lamps. The defense is taken up by third parties, the Anglo-American Brush Electric Light Corporation. The validity of both patents is put in issue. The first thing necessary is to ascertain as accurately as is possible to any one who has not had the requisite scientific training, what was known on the subject at the date of these patents, say in 1879. There are two commonly known systems of electric lighting, the arc and incandescent systems. These patents relate to the latter. The former depended upon a break in the conducting material occurring at a point where the conductor was carbon in the form of a pretty thick pencil. The current leaped over the break in an arc, gradually destroying the carbons; and this arc gave a vivid white light, especially at the positive pole. The incandescent system is different. The conducting material in this is continuous, without any break or actual interval; but, being in part an imperfect conductor, that part becomes heated by its resistance to what is called the passage of the current, and this heating, raised to an intense degree, gives the light (now familiar to us) in the incandescent lamp. The material which is now so heated is some form of carbon. It was well known that this was a good material for the purpose, because it was an imperfect conductor—in other words, had a high specific resistance—and that it was essential to use it in a vacuum or in some gas or vapor which did not contain oxygen, otherwise the carbon consumed quickly. Until 1872, when Sprengel's air pump was improved by Mr. Crookes, it was difficult to obtain a vacuum which was complete enough. The consequence was, that it was necessary to employ a pencil of carbon of comparative thickness, because there was enough oxygen left within the exhausted glass bulb to occasion some consumption of the enclosed carbon, and also enough air to diminish the bulk of the carbon when incandescent by frictional action upon its heated surface, which Edison in his specification and some of the witnesses have called "air-washing." Another difficulty which prevented the use of very slender carbons was the irregularity of the current obtained from the dynamo. It was subject to variations, which at times produced a current stronger than the carbon could bear. This was remedied by the improvements of Gramme and Brush, which were perfected in the year 1878. Two modes of improving the resistance of the carbon were known, one by increasing its length, the other by the diminution of its thickness—or, to use the more exact language of the witnesses, of its sectional area. It was known that the carbon for an incandescent lamp must be enclosed in a glass bulb from which the air must be exhausted. Bulbs made entirely of glass had been used and publicly exhibited for this purpose. It was known that molten glass could be made to adhere closely to platinum wires, because the glass proper for the purpose expands with heat in the same degree as that metal, and that for this reason, and also because of its properties as a conductor of electricity, the best mode of connecting the carbon within the glass bulb with the main wires through which the current passed, was to unite each end of it to a thin platinum wire, and to fuse the glass round these wires so that air should not penetrate at the points at which they entered the bulb. It was known that by increasing the electromotive force the main wires bringing the electric current to the lamps might be reduced in size, just—to take the illustration given by Sir F. Bramwell—as by increasing the hydraulic pressure in the pipes supplying a town with water, you are enabled to use smaller pipes, because the water will pass with accelerated velocity. It was known that by using high resistance in the incandescent portion of the lamp smaller leading wires might be employed, and also a greater number of lamps might be illuminated from the same source of electricity by working them, as Dr. Hopkinson calls it, in multiple-arc or in parallel. Two systems of using incandescent lamps were known, and it was recognized that when many lamps were to be lighted from one central station, and at some distance, the system called "multiple-arc" or "in parallel" was best. That may be shortly described as a plan involving the use of one main leading and one return wire, each lamp being supplied with electric current by a smaller wire from the main leading wire, and returning such portion of the current as it took to the return wire, the main leading wire and the return wire being supposed to be parallel. The other system, which is little employed, was the use of lamps "in series." In this case the whole current is sent through each lamp in succession, and accordingly lamps of comparatively low resistance are required. The *desideratum* in 1879, was to obtain lamps of high resistance for the "multiple-arc" system, which could be made "commercially," that is, in large quantities with reasonable cheapness, and, above all, that should have durability. Edison, Lane-Fox, Swan, and others, had been working with this object in the same direction. On the 19th of December, 1878, in a lecture given by Swan at Newcastle, he described an experiment on the production of light by passing a current of electricity from a dynamo through a slender rod of carbon inclosed in an exhausted globe. On January 17, 1879, he lectured on the same subject at Sunderland, illustrating his lecture by experiments, exhibiting certain electric lamps. On the 4th of February, 1879, he again lectured at Newcastle, and he then exhibited the lamp which has been produced in evidence. It consists of a bulb made entirely of glass with leading platinum wires sealed into it, and connected with a pencil of carbon inside the bulb. This piece of carbon was obtained from Carré, of Paris, and was manufactured by him and shaped before being carbonized. It is $\frac{1}{25}$th of an inch in diameter, that is, considerably thicker than the carbons now used, and, being straight, the leading wires are sealed into the bulb at opposite ends. This renders it liable to a defect which is alluded to in the correspondence between Swan and Mr. Stearn—viz., rupture of the carbon, or its separation from the wires by expansion and contraction under the great heat to which it is exposed. This lamp was exhibited again at Gateshead on the 13th of March, 1879, and seems to have been kept lighted for 10 to 20 minutes at a time on two or three occasions without injury. I have no evidence how long it would last if continuously used. Swan, in the spring of 1879, ordered from Carré carbons in the shape of a hair-pin, a model of which he produces. It is practically identical in form with some of the carbons now used in lamps, but with a larger sectional area. Lamps made with these would not have the defect to which I have alluded. He says that probably towards the end of 1879, he made some lamps with those hair-pin carbons. They are referred to by Mr. Stearn in a letter dated the 26th of November, 1879, in which figure 2 is a sketch of a lamp so mounted, but I do not lay much stress upon this as an anticipation of Edison, for, although Heaviside and other witnesses speak of having seen these lamps in 1879, I think the fair result of this evidence is that these were experiments which did not succeed in producing a commercially successful result before Edison's patent. On the 2d of January, 1880, Swan obtained a patent for one of the most valuable inventions connected with the manufacture of incandescent lamps. That was for preparing the carbon by passing the electric current through it, and heating it to incandescence while the bulb was still connected with a Sprengel air pump in action. This is now always done, and the effect is to make the vacuum much more perfect, or, rather less liable to be impaired by air or gas coming from the carbon itself when first heated in a vacuum. On the 21st of January, 1880, he obtained a patent for a horse-shoe strip of cardboard prepared for an incandescent lamp by converting it into a substance like parchment by treatment with sulphuric acid and then carbonizing. On the 27th of November, 1880, he obtained a further patent for the application of this process to cotton thread. This has proved a most valuable invention. It produces a non-structural tough material, said by one of the witnesses to be hard and stiff as a metallic wire, and this is now largely used for incandescent lamps. Mr. Edison applied to the object of producing a lamp of high resistance his untiring and apparently inexhaustible ingenuity, but his specification shows—as Sir F. Bramwell states—that he was not aware how much was actually then known to electricians like Lane-Fox and Swan, and

Edison conceived that he was the first inventor of some matters in which they seem to have anticipated him. Edison availed himself of the more perfect vacuum obtained by the Sprengel pump, and also of the known principle of increasing the resistance of the carbon by diminishing its sectional area, which had become possible to a much greater degree owing to the perfecting of the Sprengel air pump and the dynamo. The most important point raised upon the construction of his patent of November 10, 1879, is the extent of the second claim—whether it includes every lamp of the kind there described, the light giving carbon in which is a "filament;" or, whether it means only lamps with such filaments as are particularly mentioned in the body of the specification. Another point is upon the first claim, whether the word "lamp" in that claim does not mean merely the filament of carbon. A third question of construction is whether the carbonization of the filament is to be effected before or after it is attached to the platinum wires. With respect to the sufficiency of this specification, it is urged that Edison ought to have defined exactly what was meant by the word "filament," and that his patent of 1879 is void for insufficiency of specification in this respect, and also because it does not give sufficient directions for carbonizing filaments. None of the modes of making filaments particularly described, it is said, are practical; or, at any rate, some are not, especially the several modes of making filaments from a putty composed of lampblack and tar, and from that putty compounded or coated with various substances. Also, if the patent means that the filament is to be carbonized after being attached to the platinum wires, this, it is said, is impracticable because the platinum wires would thereby be made porous and brittle, and could not be sealed into the glass so as to prevent air getting in at the point of sealing, or through the pores in the wire. His lordship then referred to "Neilson *v.* Harford" (8 "M. and W.," 806, and "Simpson *v.* Holliday,") (13 "W. R.," 578, "L. R.," 1 H. L., 315) as to the proper mode of construing a specification, and proceeded: With regard to the construction of Edison's patent, No. 4,576 of 1879, I observe, first of all, that the provisional specification begins by stating the necessity that lamps connected in multiple should be employed without main wires of great size, and that it is essential that these lamps should have a high resistance. It is stated that this had been set forth in a previous patent of Edison's of the same year, and that lamps of great resistance had been obtained by a long wire of platinum or other metal pyro-insulated (which means coated with an incombustible substance) and coiled so that but small radiating surface was exposed. Then it is said that the present invention relates to lamps of a similar character, except that carbon threads or strips are used in place of metallic wire, and connected to platinum wires sealed into a bulb exhausted of air. A description of the mode of manufacture is then given, but not in so much detail as in the complete specification. Turning to that I find that it commences with a short statement that the object of the invention is to produce incandescent lamps of high resistance. Then follow four paragraphs stating in what the invention consists. The first of these is the coiling of carbon wire or sheets, so as to offer great resistance and present but a slight surface for radiation. The next the placing of such light giving body of great resistance in a nearly perfect vacuum. The third states that the connecting wires are platinum sealed into the glass. The fourth is the method of manufacturing carbon conductors of high resistance, and securing perfect contact between them and the wires. The specification next states Mr. Edison's view of what had been done up to that time. It is admitted that this is inaccurate in many respects. He appears to have been unaware of the attempts that had been made to do the very thing at which he was aiming —that is, to increase the resistance of the carbon burners in lamps made of bulbs of glass exhausted of air, the connecting wires being of platinum sealed into the glass. He seems ignorant that bulbs made entirely of glass had been used, or that they had been exhausted of air so as to form a vacuum. His Lordship then read Mr. Edison's description of the several modes of making the carbon burners, and proceeded: Then come the claims, which are four in number "(1) an electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance made as described and secured to metallic wires, as set forth; (2) the combination of a carbon filament within a receiver made entirely of glass through which the leading wires pass, and from which receiver the air is exhausted for the purposes set forth; (3) a coiled carbon filament, or strip, arranged in such a manner that only a portion of the surface of such carbon conductor shall radiate light as set forth; (4) the method herein described of securing the platina contact wires to the carbon filament and carbonizing of the whole in a closed chamber, substantially as set forth." I do not agree that the word "lamp" in the first claim means only the "filament of carbon." The claim is, "an electric lamp for giving light by incandescence," which the filament alone could not do. The words "consisting of" are inapt, but the wording of the whole specification is exceedingly inaccurate, and this is only an example of such inaccuracy. "Containing" would have been a better word. I construe this claim to mean lamps such as described in which the distinguishing features are carbons of "high resistance, made as described, and secured to metallic wires, as set forth." After commenting on the other claims his Lordship proceeded: The claims, as I read them, are—(2) a combination of four requisites for a lamp; (3) and (4) claims for two of those requisites separately; and (1) a claim for particular modes of making and attaching to platinum wires the first item of the combination—viz., the carbon filament. But claim (2) comprehends lamps containing carbon filaments, however made, and not only those made in the special modes described in the body of the specification and included in claim (1). The defendants construct incandescent lamps with all the four elements of the combination described in Edison's second claim. But the filament made by them is essentially different from anything particularly described in Edison's specification. His Lordship then described the defendant's mode of making the filament used by them, and continued: As I have come to the conclusion that Edison's second claim is wide enough to include any lamp with a carbon filament, however made, the defendants have clearly infringed this claim. Then comes the serious and important question whether so wide a claim can be supported. I have already pointed out that the only item of the combination which had any novelty was the use of the filament or "very slender thread" of carbon. Edison had managed to use carbons thinner than any one had used previously. The only advantage of a "filament" suggested in the specification is its high resistance by reason of its thinness or small sectional area. There was no invention described in this specification of any new principle. The principle of increasing resistance by diminishing the sectional area of the carbon was known, and had been published by Lane-Fox and by Swan before November, 1879. Assuming that Edison had been the first successfully to put that principle in practice by the methods described in his specification, did that success entitle him to say "no one shall make a lamp with a filament of carbon but myself?" Suppose the claim had been thus worded—"I have succeeded in making an electric lamp with a carbon burner, say, 1-100th of an inch in diameter, which gives a high resistance, and I claim a monopoly of all lamps with carbon burners but thicker than that, however made." Could such a claim be supported? That, in effect, is Edison's second claim. One of the objections made is that the claim ought to have been worded in some such way as I have just suggested, in order to make it sufficiently definite. In other words, Edison ought to have indicated the exact boundary between his "filament" and such a Carré carbon as Swan had successfully used. From the drawings and from the great stress laid upon coiling the filament, the only object of which seems to be to increase resistance by using a considerable length, I should conclude that Mr. Edison did not conceive that extreme thinness of the carbon was practicable. Mr. Swan had tried paper, cardboard, and similar materials carbonized, and, if he had not tried a "filament," he had used and obtained considerable success with Carré carbons not more than 1-25th of an inch in diameter. He was trying these in the form of a hair-pin, made and shaped to that form before carbonization; and it seems impossible to say that Edison, by reducing the thickness of the horse-shoe carbon, had made any vast invention or contributed largely to the knowledge which such inventors as Swan and Lane-Fox already had on the subject. His lordship then referred to "Jupe *v.* Pratt" 1 "Webst.," 146) as an authority on the right of an inventor to be protected in patenting a practical mode of applying a new principle discovered by him, and proceeded: But is there any decision that an inventor who has discovered a mode of applying a known principle like this, of increasing resistance by diminishing the sectional area of the carbon burner, can obtain a monopoly of the principle? Sir F. Bramwell, in his evidence for the plaintiff, put the case in the strongest and most favorable manner by saying that Edison made the first commercially successful incandescent lamp. Unless that is so his claim to so large a monopoly would not, in my opinion be arguable. I proceed to inquire—Did he make a commercially successful lamp—that is, were any of the modes of making lamps particularly described in the specification commercially successful? Justice Ray then referred to the numerous other electric patents taken out by Edison, and proceeded:—The plaintiffs have been challenged again and again during the cross-examination of their witnesses to prove, if they can, that any lamp with a burner made according to the description in the body of the specification of November, 1879, has been brought into the market in England or in America. No evidence of this has been given, and I conclude that there was no commercial use of the invention of that kind. Until he had taken out his subsequent patents it seems that Edison did not introduce any lamp to the public. The Justice then referred to certain experiments which had been made in constructing lamps under the patent of 1879, and continued:—With respect to the commercial success of the invention as tested by these experiments, I find from the report and a supplemental table of results which has been handed to me as an agreed statement, that out of 100 lamps some broke down at once, 13 lasted less than 10 hours, 11 more less than 20, 18 more less than 40, and only six above 40 hours, of which four were unbroken at 60 hours, and of these four there is no further record. That is far from commercial success. No system of electric lighting could be maintained, except at an expense which could not practically be incurred, with lamps of such short life as

these; and this explains most satisfactorily why Edison never sold lamps made according to the specification of 1879. In considering the sufficiency of this specification, it must be remembered that in 1879, there was no trade or business of manufacturing electric incandescent lamps. Lane-Fox, Edison, Swan, and other inventors, had given much time and attention to the subject, but except such persons there were none who had any special knowledge in the matter. The *dicta* that may be found in some cases that the specification of certain patents must be read as addressed to adepts in the particular trade or business do not apply. For this reason it was essential that the specification should be carefully explicit. It ought to be such as would enable an intelligent working man to make an incandescent lamp without having to try experiments. The Justice then examined the specification on the question of sufficiency of description, and arrived at the conclusion that it was vague and insufficient. His Lordship then proceeded,—My opinion is that the patent of Edison's, No. 4,576, of 1879, is invalid—first, because the second claim is for a monopoly of incandescent lamps containing a filament of carbon for a burner, which claim, I think, is far too wide, considering how little Edison had actually invented; secondly, because his specification does not describe a lamp which ever became, or, as I think, could have become, commercially successful; thirdly, because the directions therein contained are so insufficient that no one could have made the carbons he describes without considerable previous experiment; fourthly, because one of the processes described—viz., mixing the carbon with a volatile powder—I believe to be practically injurious if done as Edison directs; fifthly, because the coating with a non-conducting, non-carbonizing substance, if not injurious, is of no practical utility; sixthly, because the same may be said of coiling the filaments, on which the patentee lays great stress. This patent of Mr. Edison's, No. 4,576, of 1879, has been the subject of litigation in a previous suit between the present plaintiffs and Messrs. Woodhouse & Rawson, who were manufacturing incandescent lamps and were sued by the plaintiffs for infringement. The case went to the Court of Appeal, and both in the Court of First Instance and in the Court of Appeal the patent was treated as valid, though apparently with some hesitation. I am bound by these decisions, and should follow them, of course, whether I agreed with them or not, if the evidence in the two cases were the same. But that is not so. On one point which Lord Justice Cotton seems to have thought essential the courts were completely misled. They were given to understand that the carbon burner in the lamp exhibited by Swan before the date of Edison's patent was shaped after and not before carbonization. It is now admitted this was not the fact. It was a carbon made by Carré and used as made by him without alteration. But, further, I am told that there was no evidence in that case as to the difficulty of making the carbons described in Edison's patent from the description in the specification. I understand that no contest took place as to the sufficiency or utility of any part of Edison's patent, and that nothing like the evidence as to the previous knowledge on the subject was given in that trial which has been adduced in this. With respect to the construction of the patent, the opinion which I have expressed agrees with that of the majority of the learned judges in the Woodhouse & Rawson trial. The case has been brought before me with such an elaboration of evidence on every point that I think myself bound to act upon my own opinion, believing as I do that if the same materials had been before the learned judges in the other case they would have arrived at the same conclusion as I had done. The other patent in question in this action is Chesebrough's, No. 4,847, of 1878, amended by disclaimer dated November 12, 1884. The specification describes and claims a method of preparing the illuminating portion of an electric lamp, and also a material for the manufacture of illuminating carbons. Shortly stated, the carbon to be prepared is surrounded with a carbon gas or liquid and then heated intensely by the passage of the electric current. This causes a decomposition of the surrounding hydrocarbon, and the deposit upon the heated surface of an extremely dense form of carbon, such deposit being in greater quantity upon the hotter—that is, the thinner—portions. The specification states that "carbon of the ordinary sort, when heated by the electric current, exhibits points and lines of unequal brilliancy. Carbons prepared by this process when so heated glow with a uniform brilliancy throughout." A French chemist, Despretz, in experimenting on the reduction and volatilization of carbon, discovered that when the carbon was heated in an atmosphere of hydrocarbon this deposit occurred and interfered with his operations; and he describes this in a paper which was published in England some years before 1879. But Despretz did not utilize this product in any way, and his experiments had nothing to do with electric lighting. Assuming that Chesebrough derived his knowledge of the mode of producing this material from Despretz's paper, his invention consists in applying it for the purpose of making uniform the light giving power of a piece of carbon when heated by the electric current; and the beauty and merit of the invention consists in thus enabling an imperfect carbon, by a sort of automatic operation, to improve and perfect itself. I have no doubt that this is a good subject for a patent. I had more hesitation upon the claim for the material, which certainly was not discovered by him; but that is not the whole of the claim. It is for "a material for the manufacture of the illuminating conductors of electric lamps produced by electricity heating carbon in a carbon gas." That does not prevent any one from making the same material and using it for other purposes. The claim is really for the use of the material for the burner of an electric lamp. This seems to me equally valid. Another objection—that pencils cut from the lime cylinder coated with carbon would not make effective carbons—seems to me to arise from a misconstruction of the specification. It is not the lime cylinder, but the deposit of carbon which is to be made into burners. The defendants have used this process of Chesebrough's, but they say for a different purpose. Their object is to bring all their carbons to one standard of illuminating power, an operation for which they have invented a somewhat cacophonous word—"standardizing." But Sellon, one of their principal witnesses, admitted that the process would cure any inequalities of light giving surface in the particular carbon so treated. These, he says, in their cellulous carbon threads seldom occur. However, I cannot resist the conclusion that the defendants, by this use of the process for carbons of incandescent lamps, are infringing Chesebrough's patent. The plaintiffs' reply in this case was, unfortunately, interrupted. The Attorney-General asked leave, if the Court wanted more assistance on any point, to add somewhat to the reply. I have not thought it right to trouble him further. Every point has been put again and again to the scientific witnesses. Twenty-one of the working days of the Court have been occupied by this case. I have not arrived at the conclusion I have intimated without thought and care, and I do not think that further argument would be a useful expenditure of public time. I must therefore decline to trouble counsel any more in the case. I have been provided with a copy of the print of the shorthand notes. They contain, as is, perhaps, inevitable in such a case, a considerable number of verbal inaccuracies, some of which completely distort the meaning of what was said. The action, so far as it relates to Edison's patent of 1879, must be dismissed with costs. There must be an injunction to prevent any further infringement of Chesebrough's patent, and the defendants must pay the costs of this action so far as it relates to that. The costs must be set off in the usual way.

THE GAULARD AND GIBBS PATENT ANNULLED IN ENGLAND.

DECISION OF JULY 9.

Mr. Justice Kekewich, in delivering judgment, after referring on the question of nonconformity of the complete with the provisional specification, to the observations of Lord Blackburn in Bailey *v.* Robertson ("L. R." 3, App. Cases, 1,055), said that the amendment of the complete specification had the effect of substituting the specification in its present form for the original; but in its amended form it must comply with the provisions of the law, including those as to conformity with the provisional specification, as explained in Bailey *v.* Robertson. The provisional specification in the present case spoke of an "unlimited number of induction coils," whereas the complete specification spoke of "a number" only. Was this an essential difference? His lordship decided this question in the negative. One passage of the provisional specification was as follows:—"When an electric current approaches or recedes from a circuit of solenoidical form, it determines in this latter a current of induction without in any way modifying the value of the primary current." It had been said that the provisional specification depended on the statement "without in any way modifying the value of the primary current," and that this was false and was abandoned in the complete specification. His lordship continued as follows:—That that is false is conceded, and for the present purpose it may be assumed that it is abandoned in the complete specification, but I do not think that that fact is fatal to the patent. It may be important as regards utility and also relevant on the question of novelty, but it does not establish nonconformity between the two documents. The most that can be said is that the provisional specification contains, but the complete one omits, an erroneous statement respecting the patented invention which, if scientifically true, would add greatly to its value. That to my mind is not enough. But it is said that, whereas the provisional specification rests the invention on induction coils of a special construction, the complete specification as amended applies it to induction coils of every character, and this makes the latter different in the sense of being more extensive. This is a formidable objection if true. The foundation of it is the abandonment of the claim for special construction. But the patentee, though he has done this—though he has said, "I do not claim to have any special form of induction coil"—has retained, as part of his combination, the use of those of a special construction. He does not claim to construct, but he requires to use certain instruments, and those only when constructed. What is the effect of this on the complete specification standing alone is another question, but on the question of conformity I hold there is no such difference as is alleged between the two documents. Each asserts the necessity for a secondary generator of a special construction. So far, I have dealt with mere questions

of language, so as to enable the Court to read the documents for the above purpose. In further examining the specification (and henceforward I deal with the complete one only) one depends much on evidence. There are still questions of construction to be solved, but evidence is required not only to explain terms of art, but to prove what was known at the date of the patent. I may mention here one objection, out of order, to get rid of it. It has been stated by the patentee (Gibbs) that the invention is not thoroughly successful unless there is an equal mass of metal in the primary and secondary wires, and it is urged that, whether true or not, which is said to be immaterial, this ought to have been in the specification. If true, it might, with advantage, have been stated, but it only comes to this, that what is possible with unequal masses and is more feasible as you approach equality, can only be made a thorough commercial success when that equality is practically attained. I do not think that the omission to make such a statement can defeat the patent. Another objection urged respecting secondary generators was that a divided core is essential, and that this is not stated. It is, without doubt, stated as regards the first, and the evidence has satisfied me that it is sufficiently implied in the language describing the second; and further, that no electrician would stop to enquire whether a solid or divided core is intended. But, putting aside these two objections to the description of secondary generators, and assuming, of course, the soundness of my view that they are of special construction, how does the specification stand as regards the information given for their selection? And, in order to get an answer to this question, first consider what information is reasonably required? A patentee is bound to tell the public in his specification, not only what his invention is, but how practical effect is to be given to it, and if the invention be a machine, how that machine can be manufactured. I have paraphrased the statute. If there are many different ways of effecting the entire object, or any particular part of it, he is not bound to specify them all in detail, but he is bound to give such instances—selections it may be from a class—as will enable a competent workman to know what he ought to use. And he is further bound to refer to these instances, or the class from which they come, in language which leaves no doubt what articles are and what are not applicable to the production of the intended result. This is important for two reasons—first, in return for his monopoly, a patentee is bound to put the public in possession, as far as description can do it, of his invention in principle and detail; and, secondly, as a condition of being entitled to restrain other operators from producing his result by the same means, he is bound to tell them precisely what they cannot do except under penalty of an injunction with its serious consequences, and thus to indicate what can be done safely. This is not less true where the patent is for a combination than in any other case. Indeed, I am not sure that the obligation ought not in such a case to be particularly strict. If a man says, "I claim to have protected as my invention, three things combined which, though separately well known, have not been before used together," it is reasonable and right that he should state exactly what each of those three things is; and if any of them belongs to a class comprehending several varieties, then also which of the varieties are intended. And this, of course, he can easily do, as, admittedly, the combined items are well known. What is the combination, several times described, with some variation of language, but none of substance? Take it from Mr. Aston's statement to his own witness, Dr. Hopkinson. The combined elements are three in number—1, an alternating dynamo supplying a main wire; 2, a current in that wire of high tension; 3, a secondary generator such as is described. The description there mentioned is that of the witness, but of course he could only explain or illustrate, he could not go beyond the specification. In passing, let me observe that I am not satisfied that there are really three elements, but I will not dwell on this. Let it be assumed for the present purpose that there are three items—the alternating dynamo, the high tension, and the secondary generators, described in the specification. There is no difficulty about the first or second, but how has the patentee fulfilled his obligations as regards the third? It is conclusively proved by the petitioners, and not denied by the respondents, that there is nothing special about the secondary generators described, that they differ from others of their class only in unessential details, and that any other instrument of the class—induction coils with divided core—would answer the purpose equally well. So completely is this admitted by the respondents that they contest the conclusion that a special construction is intended. No more about that. Is it reasonable to hold that the divided core is the special construction? I think not. It would to my mind be pressing the maxim *ut res valeat* too severely to construe the words "electrical generators of special construction" to mean those belonging to one of two well-known and exhaustive classes, especially when one finds no reference to that class as a whole, but an elaborate description of two particular specimens. If the intention had been to refer to electrical generators having a divided core, that might have been easily done in a single line, and the examples would have been needless and out of place. Then it is urged that the special construction refers to the diminution of tension to those which, receiving an electric current of high tension, pass it on as a current of low tension. It is not pretended that this is said in so many words; no counsel or witness has ventured to put his finger on an expression which states plainly that the secondary generator employed must be of what is styled the "step-down" character. It is conceded that no other will do, and it may be assumed that no other would be attempted by a competent workman; but this is because of a well-known scientific fact, and not because of information given by the patentee There is no occasion to examine the provisional specification on this point or to inquire whether the complete specification in its original form is agreeable to the view now taken of it as amended. I hold that, as amended, it does not say one of the elements of the combination is a step-down induction coil. That is what you are to use with an alternating dynamo and a high tension primary wire, in order to produce the desired result. Nothing less than this would suffice. It is not enough to say, as the patentee does, that the quality and value of the induced currents depend on the special construction of the electrical generators without giving a plain statement in what the special construction consists. It is not suggested that the examples are exhaustive of the class of machines which would answer its purpose. I think that a manufacturer is placed by this specification in a difficulty. He knows, of course, that he cannot use either of the induction coils described, but if he wishes to use one of the same class, but differing in detail, he cannot ascertain from the specification whether he may safely do so or not. Changing the phrase, the patentee has not in his complete specification ascertained the nature of his invention, and how it is to be performed, in that he has not explained what constitutes the third item in his combination. Mr. Aston says, of course the use of equivalents would be an infringement, but I do not think that doctrine can be called in aid of a patent which professedly rests on a special construction. In its original form the specification claimed the special construction of the secondary generators required to produce the desired result. Apart from any question respecting conformity with the provisional specification, the patent could then have been supported, so far as language was concerned; but the patentee was driven to abandon this part of the claim and to amend by way of disclaimer. This was a difficult task. I am disposed to think that it could not have been performed without destroying the patent—could not, that is, have been so performed as to leave a supportable residue. But whatever was possible, I hold that it has not been done, and that, with the abandonment of the third item of claim, the whole specification falls to the ground. This holding makes it unnecessary to go into the question of anticipation. The evidence on this point is conflicting, and I have the testimony of men of acknowledged eminence and truthfulness on either side. Besides this there are many documents, and the criticism of them has been long and minute. Before pronouncing a deliberate opinion on the question I should be obliged again to examine those documents by the light of the evidence, which would have to be reperused for the purpose, and of the arguments, which would have to be recalled and weighed with regard both to documents and evidence. I do not consider myself called upon to do this; but it may be convenient for me to state what, subject to such revision as I have just mentioned, is the result of my best attention during the trial. I do not question —nobody could successfully question—the accuracy of Mr. Aston's distinction between anticipation by documents only—what is sometimes called paper anticipation—and that by manufacture or use. It is grounded on common sense and established by the authorities to which he referred, and many others. Guides for the application of the distinction are also to be found in those cases, and notably in the judgment of Lord Westbury, which Mr. Aston quoted. But the distinction concedes that there may be a paper anticipation, and the question here seems to be whether the documents which have been referred to, did not separately or together add so much to the stock of common knowledge that nothing remained for invention within the limits of Messrs. Gaulard and Gibbs' specification. Mr. Aston observed that about the years 1878-9 there was an avalanche of patents, and he accepted my suggestion that many inventors were buried in it. He did not pursue the analogy further, and perhaps forgot that a congealed mass has a law of motion of its own which after a time again brings to light, capable of recognition, though it cannot revivify, buried limbs. So here science has progressed, and in its progress has again called attention to discoveries of bygone years, long buried and forgotten, and of which Sir William Thomson was in 1881 either ignorant or oblivious. Being brought to light, they are recognized as bearing a striking resemblance to others since called into existence, and there is at least some ground for arguing that there is no substantial difference between the past and present. There is often a genuine and complete answer to an argument of that kind. Why, says the patentee of later date, why was not this old invention put in practice if, as you say, it anticipated mine, which has been proved to have been feasible and useful? It is frequently difficult—it is sometimes impossible—to give a satisfactory reply to such an objection, but I think that Sir William Thomson gave one in this case. He says that at that time, the period of those numerous patents, there was no demand for electric lighting—no encouragement, that is, for inventors to

persevere and put their inventions in practice. That would scarcely have sufficed; but he added, in effect, that there was not then known any lamp to which those inventions could be usefully applied, that failing any such lamp they necessarily slumbered, but that, such a lamp having been now discovered, their character and value are apparent. That reply, to my mind, detracts largely from the force of the objection to which I have referred. As at present advised, I fail to see how Messrs. Gaulard and Gibbs made any discovery in the technical sense of the word, or, rather, what they published to the world which was not already disclosed by some one or more of the earlier specifications. As I do not propose to examine any of them in detail I will not mention more than one, which was not, I think, the one mostly relied on by the petitioner, and possibly is not the best example. I refer to the specification of Charles W. Harrison, of March 1, 1879. You cannot, it seems, take his description of the third part of his invention any more than you can take any other of the specifications and therefrom build a complete machine according to Messrs. Gaulard and Gibbs' patent—that is, some ingenuity would be required to supplement the directions given. But are not all the necessary directions given? Do they not all concern well-known tools capable of producing well-known effects, and are they not combined precisely as Messrs Gaulard and Gibbs combine them? Mr. Aston's answer is that the secondary regenerator was employed to alter the tension, not by diminution, but by increase, not by stepping down, to adopt his favorite expression, but by stepping up. This may be true, but it was common knowledge that an induction coil might be used for alternation in either direction, and the application of it in one way instead of the other cannot be deemed invention. Again, Messrs. Gaulard and Gibbs' patent may have taught the electrical world for the first time that high tension in the primary wire is essential to successful work—in other words, that they have discovered that the best, if not the only useful mode of using the dynamo for electric lighting is by the creation of high tension. If so, they are entitled to credit for having first seen what other laborers in the same field have failed to see; but ascertaining the best use of a known tool does not fall within the proper definition of invention. The reasons which have prompted me to dispose of this case at once on the point on which I have come to a definite conclusion, and not further to consider those requiring further consideration if my judgment were to be rested on them, render it also unnecessary to deal with the question of utility, but on that I have formed a definite opinion, and it is better that I express it. Having regard to the great and rapid advance made in this particular branch of science during the last few years, one would expect an invention of 1882 to have been ere this improved upon, if not superseded, and it is not surprising, nor is it any discredit to Messrs. Gaulard and Gibbs' ingenuity, to hear that arrangements on the parallel system are found to be far more effective than those on the series system adopted by the patentees. The evidence indicated, if it did not prove, that the latter would soon give way, if it has not already given way to the former. On the other hand, I have sufficient evidence that the series system has been successful—not only tried but used and found to work with at least a large measure of success. If, therefore, I could hold the patent to be good on other ground I certainly should not hold it to be bad on the point of utility. For the reasons which I have given I am of opinion that what Messrs. Gaulard and Gibbs describe in their amended specification as their invention, and for which they claim a monopoly, is not the proper subject-matter of a patent, that, therefore, the patent granted to them ought to be revoked, and I must make an order for revocation as asked by the petitioner. The respondents must pay the costs, to be taxed on the higher scale.

ELECTRIC RAILWAY PATENTS.

S. D. Field awarded priority of Green, Hall and Siemens, by the Examiner of Interferences.

On June 23d last, the examiner of interferences of the patent office rendered a decision in the cases that had been pending several years between Green, Hall, Siemens and Field, involving the issue defined as follows:—

"The combination of a stationary dynamo-electric generator driven by a suitable motor, a circuit of conductors composed in part of an insulated or detached section of the line of rails of a railroad track, a wheeled vehicle movable upon or along said section of track, an electro-magnetic motor mounted upon said vehicle for propelling the same, and included in said circuit of conductors, and a circuit controlling device placed upon said vehicle."

The decision awards priority to Mr. Field, after a full discussion of the evidence submitted in the case.

Green, whose application was filed May 15, 1886, alleges that he conceived the invention prior to 1875, that he disclosed it to others and constructed an experimental railway in that year; using a battery as a source of electricity, and that he made a larger railway in 1876. His road of 1875 was 200 feet long, the rails were of strap iron insulated, upon timber string pieces, the car carrying a motor receiving current "through the track wheels by a wire to said motor," the wheels being insulated from the axle and the car carrying a current reverser.

Reviewing the testimony in support of Green's case, the examiner says: "It is very evident that there is nothing in the testimony * * * evidencing a full disclosure of the invention in issue." "It appears, however, that he suggested to some of his witnesses that a dynamo might be used instead of a battery, but his invention in this particular amounted to nothing more than a suggestion or mere speculation," and again: "As Green did not reduce the invention to practice prior to Field and as it is not satisfactorily shown by competent and reliable evidence, that he was first to conceive the invention, no question of diligence arises, and his case may be dismissed at this point."

Hall dates his conception of the invention in 1848, and his disclosure and reduction to practice in 1849. His application was filed July 22, 1885. He amended his date of completion to 1856. The examiner says, in respect to Hall's testimony, "It may be stated as proven that in 1848 or 1849 he made and operated the toy railroad * * * and that he exhibited the same at the fair of the Charitable Mechanics' Association of Boston in 1850. In these experiments he used a battery connected to the track rails for the purpose of supplying the current to the motor on the wheeled vehicle. This model or toy railway, it appears, contained the essential elements of the issue except the dynamo-electric generator."

The examiner was satisfied, further, that between 1856 and 1860 Hall made some experiments in the use of a magneto-electric machine to run an electric railway, but dismisses any claim to priority based on such experiments in the following language:—

"Although an electrical engineer engaged in the manufacture of electrical apparatus, he seems to have done nothing for many years, after making the models, toward perfecting and adapting the invention for practical use, and he neglected to perfect his right by applying for a patent, because, as he says, having had a wretched experience in connection with patents previously obtained on account of infringements, he considered this invention too much for him to handle, and wanted others to help him, as he knew there would be litigation about it. * * * It would appear that his present activity is due to the fact that others have interested themselves in the matter, apprised him of his neglect, and spurred him on in making an application." The examiner limits Hall to the date of his application, viz., July 22, 1885.

In respect to the Siemens application, filed October 25, 1884, it was held that from the testimony, and under the rules of the patent office in respect to foreign inventions, no date earlier than July 28, 1879, could be maintained.

OBITUARY.

Hiram Sibley.

Hiram Sibley, whose name will be ever memorable in the annals of American telegraphy, died at his home in Rochester, N. Y., July 12, at the age of 81 years.

Mr. Sibley became interested in the introduction of the House printing telegraph about 1850, and soon became a leader in the commercial development of the telegraphic art generally. His faith and foresight, his courage and persistency, his forecast of the methods requisite to place the business of telegraphy upon a broad and comprehensive basis, suited to the needs of the country at large, led to the initiation of the series of consolidations of competing interests that culminated in the organization of the present Western Union Telegraph Co, in 1866, by the absorption of the American and United States companies, the only considerable rivals of the old Western Union.

Mr. Sibley was born at North Adams, Mass., in 1807. His early education was only such as the country schools of the period could supply, and his first employment was at shoemaking. He afterwards opened a machine shop, in which he was successful enough to accumulate a small capital during 10 years work, at the end of which he removed to Rochester, where he entered into business as a banker. The new art of telegraphy attracted his attention from its earliest days, and he was one of the supporters of Professor Morse in his application to Congress for the appropriation to build the experimental line from Washington to Baltimore. Having acquired an interest in the House patents, and taken a leading part in the organization of the New York and Mississippi Telegraph Co. in 1851,—which formed but one of a considerable number of connecting or competing lines—he soon perceived the inherent defects, the results of which manifested themselves in the balance sheets, of such a conglomerate system—or no system, of telegraphic service—and set on foot measures for consolidations of interests and more comprehensive organization and management. His broad and far-reaching views met with discouragement or ridicule at the hands of many of his associates, but they ultimately prevailed; with what results, both of fortune to those who joined the movement in time, and of public benefit to the country in unifying and systematizing the general telegraph service, is well known to all observers. It is unnecessary here to recite the various steps through which one and

another small or large company was brought into line. The prominent part taken by Mr. Sibley in the complicated and delicate negotiations is sufficiently attested by the fact, that upon the consummation of the great consolidations of 1866, the old Rochester party of directors came out at the head of the combined companies, and that Mr. Sibley's associate and coadjutor, Mr. J. H. Wade, became the first president of the gigantic corporation thus created.

Perhaps the most characteristic piece of work achieved by Mr. Sibley, was the construction of the line to the Pacific, which he undertook in 1861. Surprising as it may now seem, the project was derided by his associates, whose want of faith compelled him to apply to the government for assistance. Objections and difficulties were met on every hand, but he succeeded in getting a subsidy for 10 years, of $40,000 annually, and began the work of construction July 4, 1861, completing the line on the 15th of November following. Mr. Sibley may be said to have carried this work out single handed, and in no part of his career did he exhibit more of his peculiar boldness and energy. He well merited the public applause which greeted his success. In Reid's "The Telegraph in America," Mr. Sibley's characteristic business qualities are felicitously described as follows:—"Mr. Sibley had large, quick broad ideas, was a splendid pioneer, had a sublime contempt for obstacles. * * * When he started on a crusade, like the Israelites of old, he blew his horn lustily until the walls fell; and took a complacent toot after they were down."

Mr. Sibley was generous in gifts to Cornell and Rochester universities. He provided for the erection of Sibley College of Mechanic Arts at the former, and for the library building of the latter. By will he left an endownent fund for an additional professorship at Cornell. His successful business life yielded him a large fortune and made him a power in the world; but he never lost sight of the true value of knowledge and of manual skill, regarding them—to use his own words (quoted in an obituary by the *Western Electrician*)—as "two most valuable possessions, which no search warrant can get at, which no execution can take away, and which no reverse of fortune can destroy."

MR. BROWN AND THE DOG.—A BALLAD.

Suggested by the Proceedings at Columbia College, July 30, 1888.

Then Brown he read a paper, and he demonstrated there,
That alternating arguments were exceedingly unfair.
No company employed him, and his motives he felt sure,
Were thoroughly unbiased, philanthropic, and most pure.

He had read with deepest feeling that lives were sacrificed,
And in order to prevent this, new rules he had devised.
At once, as he expected, there arose a fearful din;
And the alternating advocates hurled weighty papers in.

He took refuge in Virginia, until the sky was clear,
And after slaying sundry dogs, he shouted, "I am here."
He was a most persistent man, this modest Mr. Brown,
And labored every night and day, to save our mighty town.

To prove that he was honest, his "plant" was all in view,
And he called from out the audience three men, all good and true.
One man was set to measure ohms, another watched the volts,
The third to watch the other two, and carefully take notes.

The dog stood in the latticed box,
The wires around him led;
He knew not that electric shocks
So soon would strike him dead.

"One hundred volts we'll give him now,"
The dog did not despair;
Brown wiped the sweat from off his brow;
The dog turned not a hair.

"Two hundred more," then Brown, he cried,
The dog did not complain:
He knew not that his friends had died,—
That he must die in vain.

At last there came a deadly bolt;
The dog, O where was he?
Three hundred alternating volts
Had burst his visceræ.

EPITAPH.

Every dog must have his day;
He had his and passed away.
He never drained life's bitter cup,
Death took him when he was a pup.

THE CUSHMAN TELEPHONE SUIT.

A DECISION IN FAVOR OF THE BELL COMPANY.

Judge Blodgett handed down his decision in the suit of the American Bell Telephone Company et al., against the American Cushman Company and others, July 20, finding in favor of the plaintiffs at all points. The opinion was a long one and reviewed the testimony clearly and concisely.

The court entered an interlocutory decree, declaring the Bell patents valid and the exclusive property of the complainant company. The defendants were declared to have infringed upon these patents, and it was ordered that the complainants should recover of the defendants the profits made by them by reason of their infringement and damages sustained by such infringement. A reference to Master in Chancery, E. B. Sherman, was ordered to ascertain and report the amount of damages. Finally, the court granted a perpetual injunction against the defendants, restraining them from any futher infringement on the complainants' patents, and ordered them to pay the costs of the suit.

The Indiana company was also enjoined from opening any more exchanges or extending its business.

ELECTRIC STREET RAILWAYS IN AMERICA

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horsepower; **T.**, T rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scaife; *Sec.*, Arthur Kennedy; *Tr.*, Jas. B. Scott; *Supt.*, Alexander Moffat; *Eng.*, ——; 3-7 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 200 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½: 45 lb.; 3 m. c.; 1 m.; sta. —— h. p.; overhead cond. THOMSON-HOUSTON.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Tr.*, F. W. Harriman; *G. M.*, A. A. Jöhnson; *Eng.*, N. M. Edwards; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; sta., 60 h. p.; water power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Birmingham, Ct.—Derby Horse Railway Co.—*Pr.*, H. H. Wood; *Sec.*, Wm. J. Clark; *Treas.*, Chas. E. Clarke; 4 mi.; 94′ 8½″; m 5; c. 4; h. p. 100. VAN DEPOELE.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; *G. M.*, John Aldrich; 5 mi.; g. 4-8½; 30 and 60 lb.; 3 m. c.; 1 m.; steam power; sta. 75 h. p.; overhead cond. SPRAGUE.

Columbus, O.—Columbus Consolidated Street Ry. Co.—*Pr.*, A. D. Rodgers; 2 mi.; g. 5-2; 2 m. c.; 30 lbs.; 2 c.; sta., 250 h. p.; underground conduit. SHORT.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g.——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE. Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; *Supt.*, Mr. Richardson; 1 mi.; g. 5-2; 35 lb.; 2 m. c.; sta. 40 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1 c.; 1 m.; sta. —— h. p.; conduit VAN DEPOELE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, D. W. Burdick; *Sec.*, J. Murray Mitchell; *Tr.* T. F. Van Fleet; 1 mi.; g. 4-8½; 30 lb. T.; 2 m. c.; sta. 20 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Lafayette, Ind.—Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2.25 mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.* and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Meriden, Conn.—New Horse R. R.—*Pr.*, T. J. Lathram; *Sec.* and *Tr.*, T. A. Lamb; 5 mi.; g. 4-8½; 35 lb.; 12 m. c.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. THOMSON-HOUSTON.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. THOMSON-HOUSTON.

Richmond, Va.—The Richmond Union Pass. Ry. Co.—*Pr.*, W. R. Trigg; *Sec.* and *Tr.*, Andred Pizzini; *G. M.*; G. A. Burt; *Eng.* A. L. Johnston; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 400 h. p.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

San Jose, Cal.—San Jose & Santa Clara R. R. Co.—*Pr.*. S. A. Bishop; *Sec.*, E. Rosenthall; *Tr.*, J. Rich; *Supt.*, W. Fitts; 10 mi.; g. 3; 6 m. c.; sta. 130 h. p; conduit. FISCHER.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. McMaugh; *Eng.*, W. S. Smith; 5.75 mi.; g. 4-8½; 30 lb.; 4c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

St. Joseph, Mo.—Union Ry. Co.—*Pr.*, Seymour Jenkins; *Sec.* and *Tr.*, A. Steinacker; *Supt.*, Chas. Wilson; 9½ mi.; g. 4-8½; 35 lb.; 8 m. c.; overhead cond. SPRAGUE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Tr.* T. F. Torrey; *Supt.* and *G. M.*. B. T. Killam; *Eng.*, J. Nazel; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 14 m. c.; sta. 300 h. p.; overhead cond. THOMSON-HOUSTON.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond. THOMSON-HOUSTON.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—*Pr.*, H. H. Sen; *Sec.*, W. E. Shupp; *Tr.*, C. Walter; *Supt.*, A. C. Robertson; 3·6 mi.; g. 5-2; 50 lb.; 3 m. c.; sta. 120 h. p.; overhead cond. SPRAGUE.

Wilmington, Del.—Front & Union St. Ry. Co.—*Pr.*, G. W. Bush; *Supt.*, S. A. Price; *Tr.*, E. T. Taylor; g, 5-2; —— lb. SPRAGUE

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.5 mi.; g. 3-6; 25 lb.; 1 c.; 1 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb. T; 1 m. c.; sta. 1,000 h. p.; overhead cond. THOMSON-HOUSTON.

Constructing or Under Contract.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—*Pr.*, H. G. Bacon; *Tr.*, J. E. Draper; *G. M.*, H. M. Daggert, Jr.; 6 mi.; g. —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond.
Boston, Mass.—West End Ry. Co.—12 mi.; 20 m. c.; overhead. SPRAGUE.
Brockton, Mass.—East Side St. Ry. Co.—*Pr.*, A. F. Small; *Clerk*, C. A. Noyes; *Tr.*, C. D. Fullerton; *Eng.*, E. L. Brown; 4½ mi.; g. 4-8½; 40 lb.; 4 m. c.; steam-power sta. 60 h. p.; overhead cond. SPRAGUE.
Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.
Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown; *G. M.*, E. Scott; 4 mi.; g. 4-8½; 25 lb.
Cleveland, O.—— —— 8 mi.; 16 m. c.; overhead. SPRAGUE.
Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper; *Sec.*, J. R. Murdock; *Tr.* and *G. M.*, G. B. Kerper; *Supt.*, R. Palley; *Eng.*, H. Kolf; 1 mi.; g. 5-2½; 52 lb.; 3 m. c.; 3 m. overhead.
Davenport, Iowa.—3.5 mi.; 8 m. c.; overhead cond. SPRAGUE.
Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. THOMSON HOUSTON.
Elsinore, Cal.—Elsinore Lake Shore Elect. Ry. Co.—*Pr.*, D. G Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.
Erie, Pa.—Erie City Pass. R. R. Co.—*Pr.*, W. W. Reed; *Sec.*, J. L. Sternberg; *Supt.*, Jacob Borst.
Flushing, N. Y.—Flushing & College Point St. R. R.—*Pr.*, J. Dykes; *Sec.*, Charles Frey; *Tr.*, Henry Clement; g. 4-8½; 45 lb.; 1 mi.; storage bat's.
Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; g. 5.2½; 52 lbs.; sta. 160 h. p.; 6 m. c.; overhead cond. SPRAGUE.
Lakeside, O.—3 mi.; 2 c.; overhead cond.
Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi.; g. 4-8½; 56 lb.; 10 m. c.; storage bats.
Louisville, Ky.—Central Pass. R. R. Co.—*Pr.*, B. du Pont; *Sec.*, J. C. Donigan; —— mi: g. 5.
Meriden, Conn.—Meriden Horse R.R. Co.—*Pr.*, Geo. R. Curtis; *Sec.* and *Tr.*, C. L. Rockwell; *Supt.*, D. Barker; 5 mi.; g. 4-8; 35 lb.; 12 m. c. DAFT.
Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.
New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*. E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.
New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.
Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.
Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.
Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.
Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, F. H. Skeele; *Sec.*, E. H. Cook; *Tr.*, C. D. Newton; *V. P.*, M. Dillon; *Supt.*, T. M. Burt; 3 mi.; g. 4-8½; 38 lb.; 5 m. c.; overhead DAFT.
Revere, Mass.—Lynn & Boston R. R.—Ocean Ave. line; overhead cond. THOMSON-HOUSTON.
Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.
St. Louis, Mo.—Lindell Ry. Co.—*Pr.*, J. H. Lightner; *Supt.*, G. W. Baumhoff; *Eng.*, E. J. Bagnall; —— mi.; g. 4-10; 65 lb.; 1 m. c.; 2 m.; 3 p. c.; storage bats.
Sacramento, Cal.—Sac. Elect. Ry. Co. The Central Street Railway Co.—*Pr.*, L. L. Lewis; *Sec.*, E. K. Alsip; *Tr.*, F. Miller; *Supt.*, J. B. Austin; *Eng.*, ——; 13 mi.; g., 4-8½. Cars to be supplied by Electric Car Co, of America, Philadelphia.
Salem, Mass.—Naumkeag St. Ry. Co.—*Pr.*, C. Odell; *Tr.*, H. Wheatland; *Sec.*, J. F. Hickey; *Supt.*, W. B. Furgurson; 1½ mi.; g. 4-8½; 6 m. c.; 35 lb.; 80 p. c.; sta. 100 h. p.; overhead cond. SPRAGUE.
Sault Ste. Marie, Mich.—S. St. M. St. Ry. Co.—*Pr.*, E. M. Lacy; *Sec.*, F. Ryan; *G. M.*, L. G. Cody; 2 mi. FISHER.
Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.*, A. Frothingham; *Tr.*, G. A. Jessup; *Supt.* and *Eng.*, T. Gibbs; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; steam power; sta. 250 h. p.; overhead cond. VAN DEPOELE.
Scranton, Pa.—The People's St. Ry.; overhead. SPRAGUE.
South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.
Springfield, Mo.—2 mi. FISHER.
Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.
Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; *G. M.*, H. McGonegal; 4 mi.; g. 4-8½; 8 m. c.; 4 p. c.; steam power; sta. 250 h. p.; overhead cond. THOMSON-HOUSTON.
Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

Notes.

WILMINGTON, DEL.—Mr. Wm. Canby, president of the Wilmington City R. W. Co., whose electric road (Sprague) with overhead conductors has now been in operation over four months, expresses his entire satisfaction, endorsed by the board of directors, with the results, both practically and financially. Mr. Canby says:—"We consider it by all odds the best and most economical mode of running street cars in suburban districts, or in any place where permission to erect poles can be obtained. In comparison with horse-power, we find it decidedly cheaper and more efficient in every way."

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From June 19 to July 17, 1888 (inclusive).

Alarms and Signals:—*Electric Fire Apparatus*, G. M. Stevens, 384,875, June 19. *Electric Signal Transmitter*, W. C. Thompson, 385,388, July 3. *Electrical Annunciator*, M. M. Wood, 385,894, July 10. *Police Signal Apparatus*, J. C. Wilson, 386,175. *Electrical Bulletin*, P. B. Delany, 386,189, July 17.

Clocks:—*Secondary Electric Clock Movement*, C. Bohmeyer, 386,108, July 17.

Conductors, Insulators, Supports and Systems:—*Insulated Conductor*, C. C. Sibley, 385,576, July 3. *Electric Conductor*, L. Daft, 385,915, July 10. *Electric Wire Insulator*, H. H. Cutler, 386,111, July 17.

Distribution:—*System of Electrical Distribution*, T. A. Edison, 385,173, June 26. *Electrical Distribution by Storage Batteries*, G. W. Walker, 386,225, July 17.

Dynamos and Motors:—*Dynamo-Electric Machine*, R. Oliver, 384,688. *Commutator for Dynamo-Electric Machines*, J. J. Wood, 384,816, June 19. *Dynamo-Electric Machinery*, A. Reckenzaun, 385,068, June 26. *Dynamo-Electric Machine*, A. Harding, 385,458. *Electric Motor and Dynamo-Machine*, O. Lugo, 385,675, July 3. *Commutator for Dynamo-Electric Machines*, F. B. Mitchell, 385,943. *Magneto-Electric Machine*, W. Humans, 386,071, July 10. *Dynamo-Electric Machinery*, G. Miot, 386,340, July 17.

Galvanic Batteries:—*Galvanic Battery*, C. A. Brown and M. M. Clark, 384,958. *Electrolyte for Galvanic Batteries*, B. J. Wheelock, 385,028. *Galvanic Battery*, E. E. Starr, 385,147. *Battery Zinc*, J. Doyle, 385,254. *Electric Battery*, E. M. Hewett, 385,308, June 26. *Porous Cup for Galvanic Batteries*, A. K. Eaton, 385,344, July 3. *Electric Battery*, W. P. Kookogey, 385,760. *Electric Battery*, I. L. Roberts, 386,090, July 10. *Galvanic Battery*, A. V. Meserole, 386,149 and 386,150, July 17.

Ignition:—*Magneto-Electric Fuse*, E. L. Zalinski, 384,662. *Electric Gas-Lighting Device and Gas Cock*, W. Tag and S. C. Smith, 384,796, June 19. *Method of Blasting*, M. Widdell, 386,281, July 17.

Lamps and Appurtenances:—*Incandescent Lamp Socket and Switch*, J. J. Wood, 384,815. *Electric Arc Lamp*, J. J. Wood, 384,817, June 19. *Electric Light System*, B. E. Sunny, 385,020. *Holder for Incandescent Lamps*, W. A. Carey, 385,039, June 26. *Electric Lamp Socket*, J. S. Adams and A. W. Morrell, 385,436. *Suspension Arm for Electric Lamps*, J. J. Wood, 385,498, July 3. *Arc Lamp*, J. E. Gaston, 385,705. *Automatic Cut-Out for Incandescent Lamps*, M. J. Wightman and H. Lemp, 386,099, July 10.

Measurement:—*Electric Meter*, E. Thomson, 385,647, July 3.

Medical and Surgical:—*Medicated Electric Belt*, C. U. Hoke, 385,556, July 3.

Metallurgical:—*Magnetic Separator*, M. H. Smith, 384,645, June 19. *Sluice Box*, J. H. Rae, 386,030, July 10.

Miscellaneous:—*Electro-Magnetic Parcel Carrier*, M. C. Mengis, 384,775. *Rack for Electroplating*, W. W. White, 384,806. *Electro-Magnetic Time Lock*, C. J. Kintner, 384,856. *Electric Stopping Mechanism for Looms*, E. A. Smith, 384,934, June 19. *Rheostat*, J. W. Packard, 385,001. *Apparatus for Electric Welding*, E. Thomson, 385,022. *Electric Switch*, P. J. Tracy, 385,023. *Switch for Electrical Purposes*, W. A. Carey, 385,041. *Mariner's Recording Compass*, H. A. Chase, 385,042. *Electric Alarm Compass*, same, 385,043. *Electric Cut-Out*, C. G. Perkins, 385,067. *Lightning Escape for Wire Fences*, A. Cockrell, 385,095. *Method of Generating Electricity and Purifying Water*, J. E. Siebel, 385,145. *Electrical Pumping Apparatus*, F. J. Sprague. 385,211. *Steering Apparatus for Vessels*, B. A. Fiske, 385,259. *Electro-Magnetic Dental Hammer and Plugger*, P. Helmer, re issue, 10,940, June 26. *Method of Joining Pipes by Electricity*, E. Thomson, 385,384. *Method of Electrically Welding Chains and Links*, E. Thomson, 385,385. *Direct Electric Welding Machine*, E. Thomson, 385,386. *Cut-Out*, C. D. Wright, 385,494. *Relief Die and Process of Making the Same*, G. F. and J. W. McIndoe, 385,519. *Electric Switch*, E. F. Bergman, 385,539. *Electro-Mechanical Type-Writer*, J. F. McLaughlin, 385,565, July 3. *Protector for Electrical Instruments*, G. W. and W. Mingle, 385,770. *Electric Switch*, S. S. Wheeler, 385,782. *Electrical Switch*, J. E. Mayo, 385,815. *Graphophone*, C. S. Taintor, 385,886. *Graphophonic Tablet*, C. S. Taintor, 385,887. *Automatic Weighing and Recording Apparatus*, E. H. Amet, 385,900. *Coin Operated Induction Coil*, J. W. Hazell, 385,927. *Apparatus for Tilling Ground*, E. R. Whitney, 385,984. *Electric Lock*, F. J. Gridley, 386,066. *Method of Welding by Electricity*, E. E. Ries, 386,068, July 10. *Apparatus for Electric Welding*, E. Thomson, 386,441. *Electrical Conductor*, E. Weston, re-issues, 10,944, July 17, same, 10,945.

Railways and Appliances:—*Automatic Electric Gas Cut-Off for Railroad Cars*, F. C. Brower, 384,676. *Electric Railway*, S. D. Field, 384,685. *Automatic Electric Block-Signal System*, T. D. Williams and J. S. Lucock, 384,810. *Apparatus for Operating Automatic Block Signals*, same, 384,811. *Railway Signaling*, T. A. Edison and E. T. Gilliland, 384,830. *Guard Rail and Insulator for Electric Railways*, H. A. Foster, 384,901. *Electric Railway*, R. M. Hunter, 384,908, 384,909, 384,910, 384,911 and 384,912, June 19. *Electric Railway Signal*, S. C. C. Currie, 384,962. *Electromotive Railway*, G. T. Woods. 385,034. *Electric Railway*, R. M. Hunter, 385,053, 385,054 and 385,055. *Electric Railway*, G. H. Condict, 385,097. *Electric Railway*, R. M. Hunter, 385,180. *Electrical Connector*, F. Stitzel and C. Weinedel, 385,215, June 26. *Switch Signal*, A. F. Martel, 385,363. *Current Collector for Series Electric Railways*, S. H. Short, 385,379. *Electric Railway Power and Lighting Appliance*, I. W. Heysinger, 385,413. *Device for Securing Wire to Railroad Rails*, F. Stitzel and C. Weinedel, 385,484. *Electric Railway*, R. M. Hunter, 385,672. *Railway Signal*, A. F. Martel, 385,677, July 3. *Electric Motor for Street Cars*, W. S. Salisbury, 385,727. *Device for Lighting and Heating Cars by Electricity*, De Witt C. Roberts, 385,774. *Electric Railway System*, E. M. Bentley. 385,787. *Railway Signal Lantern*, C. H. Peters, 385,877. *Electric Railway*, E. M. Bentley, 385,902. *Switch on Overhead Lines in Electric Railways*, E. M. Bentley, 385,903. *Railway Signal*, C. F. DeRedon, 385,920. *Electric Railway*, E. W. Heald. 385,928. *Electric Signal for Railways*, E. A. Sharp, 385,964. *Railway Signal*, G. H. Wright, 386,049. *Electric Railway*, E. E. Ries, 386,085. *Driving Mechanism for Electric Railway Cars*, E. E. Ries, 386,086. *Combined Electric Railway and Wire Conduit*, E. E. Ries, 386,087, July 10. *Electric Railway*, R. A. Chesebrough, 386,184. *Tunnel Construction for Electric Railways*, G. T. Woods, 386,282, July 17.

Storage Batteries:—*Secondary Battery*, A. Reckenzaun, 385,200, June 26. *Secondary or Storage Electric Battery*, S. L. Trippe, 385,390. *Secondary Battery*, F. King, 385,558, July 3.

Telegraphs:—*Telegraph Relay*, F. Stitzel and C. Weinedel, 385,214, June 26. *Telegraphic Recording Apparatus*, C. Cuttriss, 386,059, July 10. *Automatic Telegraph Transmitter*, Z. P. Hotchkiss, 386,129, July 17.

Telephones, Systems and Appliances:—*Multiple Switch-Board Testing Apparatus*, C. E. Scribner, 384,614, June 19. *Test System for Multiple Switch-Boards*, C. E. Scribner, 385,205, June 26. *Combined Speaking and Signaling Apparatus*, J. E. Kelly, 385,357. *Test Signal Circuit*, C. E. Scribner, 385,482. *Spring-Jack Switch*, C. E. Scribner, 385,528. *Telephone Transmitter*, J. Emmner, Jr., 385,664, July 3. *Multiple Switch-Board*, A. Sechrist, 385,826. *Mechanical Telephone*, L. D. Brear, 385,839. *Wiring Switch-Boards*, J. A. and F. B. Cook, 385,846. *Multiple Switch-Board*, M. G. Kellogg, 385,863. *Electric Telephone*, N. Parks, 385,956. *Telephone Central Station Apparatus*, T. N. Vail and J. A. Seely, 385,974, 385,976 and 385,977. *Telephone Sub-Station Apparatus*, same, 385,975. *Telephone Exchange Signaling*, same, 385,978, July 10. *Mechanical Telephone*, F. E. Clarke, 386,238. *Telephone Transmitter*, C. W. Brown, 386,380, July 17.

G. W. Stockly

E M Barton

H M Byllesby

Ronald T. McDonald

THE

ELECTRICAL ENGIN[illegible]

[illegible] F. L. P[illegible]

[illegible]

[illegible] Wall Street, New York [illegible]

TERMS OF SUBSCRIPTION.

[illegible]

EDITORIAL ANNOUNCEMENTS.

[illegible]

N[illegible] NEW YORK, SEPT[illegible]

ELECTRIC LIGHT [illegible]

C[illegible] ways in which the business [illegible] of the business of [illegible] collection of royalties, [illegible] found so attractive [illegible] supplies has since been conducted under vigorous competition [illegible] and [illegible] prices. While inventors [illegible] activity on all sides, and the [illegible] have been eager to secure [illegible] in their art, the bulk of [illegible] with [illegible] regard to patent [illegible] have confined their [illegible] quality and cost of an [illegible] being sought, with little if any regard to [illegible].

During the past [illegible] the [illegible] companies manufacturing electric [illegible] largely centered in the alternating [illegible] former method. The Gaulard and [illegible] on this system has met with a [illegible] with opponents in court, whatever [illegible] may be. But successful [illegible] currents involves a number of problems [illegible]

THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS.

PUBLISHED MONTHLY AT

11 Wall Street, New York City.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies, -		.30

[*Entered as second class matter at the New York, N. Y., Post Office, April* 9, 1888.]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed*, EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers*

VOL. VII. NEW YORK, SEPTEMBER, 1888. No. 81

ELECTRIC LIGHT COMPETITION.

COMMENTING upon the situation of the electric lighting industry two years ago, THE ELECTRICAL ENGINEER, of August, 1886, used the following language: "At present there is apparently not sufficient control of fundamental features of arc or incandescent lamps, or of dynamos, by virtue of patented inventions, in the hands of any single interest or combination, to justify any material taxation of the business of lighting in the way of royalty." The exaction of royalties, whether in the form of stock in local companies or otherwise, had then well nigh, if not entirely, been discontinued, and business in electric light machinery and supplies has since been conducted under conditions of strenuous competition by both arc and incandescent companies. While inventors have increased in numbers and activity on all sides, and the various electric light companies have been eager to secure patents upon improvements in their art, the bulk of the business has been transacted with small regard to patent questions. Purchasers of plant have confined their attention for the most part to the quality and cost of an outfit; the best and cheapest being sought, with little if any regard to possible patent complications.

During the past two years the interest in patent questions of the companies manufacturing electric light plant has been shifted chiefly to inventions in methods of distribution, and has largely centered in the alternating current and transformer method. The Gaulard and Gibbs' American patent on this system has met with a rebuff in its first encounter with opponents in court, whatever its ultimate success or failure may be. But successful distribution by alternating currents involves a number of problems quite beyond and in addition to the general principle of the Gaulard and Gibbs' patent, problems that are attacked with varying degrees of success by the several companies that have ventured into the new field; and for some time to come there will be energetic competition for business between them unless the strain lead to a combination of interests at an early day. The latter contingency seems not unlikely, as we recently said in these columns. We would not like to see an Electric Light Trust established, after the manner of some of the great combines of the day, nor do we imagine that such a thing is likely to come about; but the conditions under which the business is carried on at this time, the severity of competition, and the throwing open to general use, temporarily or permanently, through decisions of the courts in patent suits, of several inventions that have been regarded as fundamental, seem favorable to the establishment of greater community of interests than now exists among the leading companies.

In view of what has happened in analogous enterprises the present tension and uncertainty of their mutual relations would seem to suggest with much force to leading companies the policy of consolidation or coalition.

Meantime there is no complaint of any lack of business. Central station incandescent work has had a remarkable impetus since the advent of alternate current distribution some two years ago; and there can remain no doubt of the permanent value of that system for widely extended districts. Perhaps the best proof of its great utility is found in the number of electric companies that have committed themselves to its employment.

THE ELECTRIC LIGHT ASSOCIATION.

As we go to press with our September number the National Electric Light Association will be engaged in the early sessions of its semi-annual meeting, August 29–31, at the Hotel Brunswick, New York. Papers are expected to be read as follows:—Dr. Louis Duncan, of Johns Hopkins University, relating to tests made by himself and his associates; Professor E. L. Nichols, of Cornell University, subject not announced; O. B. Shallenberger, "Measurement of Alternating Currents for Commercial Purposes;" E. G. Acheson, "Disruptive Discharges in Underground Conductors;" C. C. Haskins, "Some Practical Pointers;" S. S. Wheeler, "Electric Conductors in New York;" F, B. Crocker, "The Ideal Motor;" Wm. Lee Church, "Electrical Steam Engineering;" Dr. Leonard Waldo, subject not announced.

Among other important business to come before the convention will be a revision of the constitution of the association, a committee having been appointed at the Pittsburgh meeting in February last to prepare amendments and to report them at the August meeting. In this connection we take the liberty of calling attention to the possible, or in our opinion probable, desirability of dispensing with the semi-annual meetings after the current year. The winter meetings have been better attended and of greater interest and usefulness than the semi-annual or summer conventions, and the association has now, it seems to us, acquired sufficient stability to be able to maintain its position and increase its usefulness with an annual meeting

only. The permanent secretary, together with the executive committee, can well preserve the continuity of the work of the association for a year. It seems extremely probable that the elimination of the semi-annual or summer meeting would result in an increase in attendance at the annual meeting and further accession of desirable memberships. There is plenty of time to think over the matter before the annual meeting next winter.

A complete report of the present convention, including all the papers read and their discussion will be published in an extra number of the ELECTRICAL ENGINEER soon after the adjournment of the association.

THE annual meeting of the National Telephone Exchange Association closely follows the Electric Light Convention, at the same hotel, New York city, assembling Tuesday, September 4, at 11 A. M. It is expected that two days will be devoted to business and a third to visits to points of interest in and near New York under the good offices of local members, to whose guidance members from a distance, on knowledge or pleasure bent, may confidently entrust their local travels.

UNDER the encouragement of the Electric Lighting Act of 1888, recently enacted by Parliament, which is more favorable to electric lighting interests than the Act of 1882, central station lighting is about to be undertaken in London on a large scale.

We are in receipt of the prospectus of the "Metropolitan Electric Supply Co., limited. Capital £500,000, in 50,000 shares of £10 each, being 49,900 ordinary shares and 100 fully paid founder's shares; to be increased from time to time as the works extend." Sir John Pender is chairman of the company, and the directory includes such well-known names as Sir George Elliot; Admiral Sir George H. Richards; Sir James Anderson; J. E. H. Gordon, Esq.; Henry Weaver, Esq., and others. The directors express their belief "that the time has arrived when the great work of electric lighting may be undertaken on a scale which will largely meet the requirements now supplied by gas, and that it can be established on a sound scientific and commercial basis." The company announces its purpose to construct works at once in the parishes of St. James, Westminster (Piccadilly), and St. Martin's-in-the-fields, districts embracing many of the principal hotels, clubs and theatres; and states that it has contracted to take over the undertaking of the Whitehall company, including their works now nearly completed. The prospectus states that "the company is not committed to any particular patents or systems, but is quite free to adopt any system which promises favorable results."

In justification of the expectation of commercial success the promoters of the London company quote the earnings of a considerable number of American electric lighting companies. While the authenticity of some of the figures given might be questioned, there is no doubt that well planned and carefully managed central station plants can and do yield good profits. The average of the figures quoted is large enough to permit a considerable abatement and still leave a satisfactory percentage.

THE opinion of Judge Colt, of the U. S. Circuit Court, Massachusetts, broadly upholding the Thomson-Houston regulator patent, printed in another column of this issue, constitutes, we believe, the first instance in which an important electric lighting patent has been sustained by a United States Court and declared to have been infringed. Considering the comprehensive character of the claim sustained in this decision, a considerable number of arc light companies will probably find themselves obliged to make terms with the Thomson-Houston company. Most, if not all, the automatic current regulators so freely used in arc lighting would seem to come under the terms of the Thomson-Houston claim. There seems to have prevailed a somewhat general impression that the patent could not be maintained in court.

MR. ANTHONY RECKENZAUN's series of articles on the Construction and Management of Storage Batteries in the *Telegraphic Journal and Electrical Review* of London, which was interrupted nearly a year ago, is now continued in that journal. Two installments of the resumed series are reprinted in the present number of the ELECTRICAL ENGINEER, continuing our reprint of the earlier papers. Mr. Reckenzaun makes liberal use of his experience and observations in America last summer and fall. His wide experience with storage batteries lends interest and value to his writings on the subject, particularly in view of the apparent uncertainty at the present time in respect to the ultimate value of accumulators in electrical distribution on a large scale.

THE Ohio Valley Centennial Exposition, at Cincinnati, to open September 4th, will comprise an extensive and varied exhibition of electric lighting. The outfits shown by the several companies exhibiting will be used in illuminating the grounds and buildings. Plants will in this way be shown in operation by the following companies:—The Western Electric Co., eight dynamos and 225 arc lamps; the Waterhouse Electric Co., eight dynamos and 230 arc lamps. Three thousand incandescent lamps, fed by six 500 light dynamos will be shown by the Edison, Queen City, and Mather companies, in equal portions. These lighting plants will be run by engines exhibited by the following companies:—The Buckeye Engine Co., of Salem, O., the Atlas Engine Co., of Indianapolis, Russell & Co., of Massillon, O., and the Ball Engine Co., of Erie, Pa. The Cincinnati Exposition promises to be of much interest as an industrial display.

AMONG the many rules suggested or adopted in various localities for the regulation of electric light circuits, the proposition of Mr. S. S. Wheeler that "an arc lamp within the reach of any man's umbrella is hung too low," is such an obviously common sense suggestion as to commend itself everywhere.

The writer of the communication on "Gravity Battery *vs.* Dynamos," signed D. S., in *Letters to the Editor*, ELECTRICAL ENGINEER for July, desires to correct an error in the eighth line from bottom of page 320, where "one volt and two amperes" should read one volt and two *ohms*.

OBSERVATIONS.

A GREAT many people now living have at one time or another experienced some kind of electric shock. John Tyndall tells how he was blotted out, on the lecture platform one evening, by receiving the combined discharge of a number of Leyden jars, and that on resuming his existence, he found that he had been absent from the body, so short a time that the audience had not noticed anything wrong; which gives color to the statement of Mahomet that he was taken from his bed, carried to the third heaven, and retained there for a long time, but that returning to his bed, he found it still warm. Circumstances have lately led the observer to enquire regarding the sensations of people who have received the violent shock of a dynamo current, *straight*. All whom he has been able to interrogate concur in stating that when sensation returned, it returned piecemeal as it were. Each had a decided impression that he was totally dismembered, that every member of his body was in a number of fragments, and that the several fragments in recovering from the shock, were gradually once more coming together; and that the several members were slowly getting into place. One man graphically described the anxiety with which he waited, with bated breath, and absolutely a fear to move, lest something should join itself to something else, wrong end to; and said he was especially afraid that his finger nails would come back with the outward end in, and become so fixed.

Who will rise and explain this? Perhaps it may be a phenomenon of the direct current only.

. . .

THE above was brought to mind by reflecting upon the dog experiments of Mr. Harold P. Brown, Electrical Engineer, *et al.* Is'nt it rather hard lines to be a dog in these scientific times? The proverb says "Every dog has his day," but it may well be imagined that if his day is to be an electric day he could easily be persuaded to forego it.

. . .

PASSING from types and shadows to symbols, and thinking once more of the same proverb,—are not the candle of Jablochkoff (that burglarious name) and its congeners, something like the dog in their evanescence? To be sure, the Jablochkoff, the Jamin and Wilde candles are now hard to find; they have been outshone and out-distanced by the regulating arc lamps, and now none are so poor as to do them honor; but who can or who would care to deny, that they have had their day, and a glorious day at that?

Was it not these candles first that made arc lighting a commercial success; showing that several arcs could be burned in series; and more than this, showing that the necessary thing for the long maintenance of light without attendance, was the initial provision of a number of pairs of carbons, and of an automatic contrivance for substituting the second and third pairs, as the prior ones were consumed; the pioneer thought of the double carbon mechanism lamps of the present day. All honor then to the candle, as having lighted us on the way to a more brilliant career of electric illumination.

. . .

TALKING and writing about the discovery of the electric arc light, we rightly ascribe it to Sir Humphrey Davy. But we nearly always give the date as 1809. It seems, however, that if Davy did not actually hit the bull's eye in 1800 and 1802, he got at least within the centre circle.

Nicholson's Journal, for October, 1800, contains a letter signed by Davy, which states that he has discovered that "well-burned charcoal possesses the same properties as metallic bodies in producing the shock and *spark when made a medium of communication between the ends of the galvanic pile of Signor Volta.*"

And in the *Journal of the Royal Institution*, vol. i., of 1802, Davy describes some experiments upon the sparks yielded by the voltaic pile, and states, "When instead of the metals, pieces of well-burned charcoal were employed, *the spark was still larger and of a vivid whiteness.*" One is inclined to think that this spark was a true arc as now understood.

PROBABLY nearly every electric arc lighting company owning a system (?) now electroplates its carbons. There was in the dark ages of 1879, an interference in our much abused patent office, between the two well-known inventors, Charles F. Brush and Moses G. Farmer, in relation to the coppering of electric light carbons, and it was held by Paine, Commissioner, that Farmer had invented the process in controversy, before Brush; but had also abandoned it, so that while priority was therefore awarded to Brush *pro forma*, the invention was thrown open to the public by Farmer's prior invention, and failure to patent.

But as a matter of fact Jablochkoff, had as early as 1876, plated the carbons of his candles with copper; and though the invention had prior to that time been patented in France by Reynier, Jablochkoff disdained to recognize the Reynier patent, depending upon prior patents and publications; and it appears that Jablochkoff was right, since the Reynier patent was subsequently voided by the French courts, and held to be anticipated by a prior Carré patent; and by Van Malderen's work in 1868. Bouliguine and Tchikoleff, also in Russia, plated their carbons, and published accounts of their practice.

The history of this feature of electric lighting is closely paralleled by many other features; and all other branches of applied electricity likewise disclose similar instances of anticipation. Electric lighting, however, is so old an art in itself, although commercially young, that inventors in this field cannot go far without running foul of something which had been invented (though very likely not much employed) years before.

And they acquire a decided impression, which they may voice, as others have done before them, in the complaint that "the people of *former times* had little honesty, they have stolen all my inventions."

. . .

ACCORDING to one of our New York E. C.'s., "San Diego, Cal. has adopted the Westing*home* system of incandescent lighting." To be sure; isn't an 'ouse, an 'ome?

. . .

AT a recent regular quarterly meeting of the New Englan Electric Exchange, Mr. Geo. F. Curtiss read an eloquent and able paper upon "Lightning Arresters." Mr. Curtiss, speaking of the telegraph switch-board lightning arrester, says: "All of these serve their purpose on lines of low potential, as for instance telephone, telegraph, fire alarm, etc." It is hardly fair to criticise adversely the only weak spot in an otherwise excellent paper, were it not in the general interest; it would, however, be interesting to know the process of reasoning whereby Mr. Curtiss reaches the conclusion that telephone lines carry currents of low potential, for that is probably what he means.

An electric current capable of passing through 12 persons, in series, each clasping hands with the person on either side, would, to the observer, even though he be but an ordinary one, seem to be very fairly equipped in the matter of potential.

. . .

THE Society of Telegraph Engineers (England) was organized at the beginning of the year 1872, and the first general meeting was held on the evening of February 28, 1872.

This society has been the most successful and far-reaching one of its kind, as its 16 well-filled annual volumes of proceedings testify. During the early part of its history the subjects brought before it for discussion were almost exclusively of a telegraphic character, for the very good reason that telegraphy was the only important application of electricity up to the year 1877.

The telephone and electric light produced a change in this respect, and some years ago the society added to its already long name the words "and Electricians." It is now considering again the subject of a change of name, and seems inclined to adopt some title which shall more fully indicate the character and scope of the work which by the force of circumstances it has been compelled to assume. The tone and merit of the papers read and of the discussions during the last three or four years, seem scarcely up to the high standard of the years when the society

was young; and a hasty judgment would ascribe this partly to the introduction of subjects connected with rival business interests, and partly to the circumstance that the new science of electricity with its dependent arts has grown so fast, and is still growing so fast that it is impossible to formulate definite opinions with any well grounded hope, that they will not within a year or two be upset by experience. The society is, however, an example to us on this side of the water, in that it does bring forward a large number of subjects for discussion, and that its programmes are as liberal in variety as they are in amplitude.

Some of our electrical societies in America seem to regard their function as being the establishment of an electrical arena wherein the respective advocates of direct incandescent lighting, and the converter (or as they call it in Great Barrington, Mass., the "*exhorter*") or alternating systems may fight it out. Of course all this tends to increase knowledge, and also to emphasize the self-evident fact that "there is much to be said upon both sides," as the monkey remarked while acting as umpire; nevertheless one gets tired of even canvas-back duck, if one gets it three times a day for a month, and it is to be hoped that our societies (they mostly call themselves "clubs") will not get into a rut, but will occasionally treat us to a new bill of fare.

• • •

BICYCLIST Thomas Stevens, who is not less entertaining as a writer than he is enthusiastic as a wheelman, tells in one of his letters his delight at seeing a telegraph line in Persia. Teheran, Ispahan and Shiras are the principal telegraph stations in the land of the Shah; but there are, of course, other offices, some of them being dreary and lonely indeed for the operators. Mr. Stevens is a genuine American, but he pays a deserved tribute to the solidity and thoroughness of British telegraph line construction. The observer confesses that our English cousins do surpass their American relatives in this respect. But then we must not forget that, although Julius Cæsar was not an electrical engineer, he did show the Britons how to make good roads, while the American Indian who formerly prowled around this land of ours, always tried to walk in the narrow way. The different ways of the former possessors of our respective countries may have something to do with the case.

SOME PROMINENT MEN IN ELECTRIC LIGHTING.

(See Frontispiece.)

GEORGE W. STOCKLY.

PRESIDENT, BRUSH ELECTRIC CO.

MR. GEORGE W. STOCKLY has been conspicuously identified with the development of electric lighting throughout its commercial history, as president and general manager of the Brush Electric Co. from its inception. A native of Cleveland, Ohio, which city has always been his home, Mr. Stockly will attain his forty-fifth year December 20 next. At the present time he has accomplished work and achieved results, both in reputation and fortune, which would well occupy and reward the efforts of a long life.

Mr. Stockly's school training did not extend beyond that afforded by the public grammar and high schools of his native city. He was strongly inclined to the profession of law, and on leaving school in 1861, he began legal studies in the office of Messrs Willey & Cary, a prominent law firm of Cleveland. At the end of two years the death of his father threw upon him such responsibilities for the care of the family, that he felt obliged to relinquish his cherished desire for a legal career, and to seek immediately remunerative employment. He began commercial life in the commission house of Messrs. Bond & Morris: subsequently, and until his first connection with electrical business in 1873, he held positions in the offices of the Cleveland and Pittsburgh Railroad, the Cleveland Omnibus Line, and in the Commercial National Bank of Cleveland. In the latter connection he served as receiving teller two years and as paying teller five years.

In March, 1873, Mr. Stockly, together with Mr. John E. Cary (of the law firm with whom he had studied twelve years earlier), bought a large interest in the business of the Cleveland Telegraph Supply and Manufacturing Co., which had been founded the previous year under the presidency of the late Geo. B. Hicks. Mr. Stockly left the bank and took charge of the business of the company as vice-president and manager. Mr. Hicks died a month later, and Mr. Stockly found himself thus charged with well-nigh the sole conduct of a difficult business, with which he had little acquaintance and no experience. The situation spurred him to the labor of mastering the business in all its details. How successfully he did this is shown by his remaining at the head of the management of the company, and its successors up to the present time. The company was soon reorganized under the name of the Telegraph Supply Company. Although less than fifteen years ago, the period was a day of small things in electrical business. The company's force of workmen numbered not more than twenty, and there were but few larger electrical shops in the country. The electric light was wanted for use and needed for business, and it came along, reaching the young company at the hands of Mr. Chas. F. Brush during the winter of 1876-'77. Mr. Brush's successful invention and production of dynamos and arc lamps became the foundation of the great manufacturing and commercial business since and now carried on under Mr. Stockly's management. In 1880 the name of the company was changed, very appropriately, to the Brush Electric Co. The little shop has grown to a number of buildings, covering several acres of land, and giving work to about seven hundred men. With able associates in the directory of the company, Mr. Stockly's admirable business qualifications have fully supplemented Mr. Brush's inventive talent and mechanical skill in achieving the remarkable commercial success of the company.

ENOS M. BARTON.

PRESIDENT, WESTERN ELECTRIC CO.

MR. ENOS M. BARTON was born in Jefferson County, New York, December 2, 1842, and descends, on the side of both father and mother, from an English ancestry by way of New England. When a lad of about twelve years he began work as a telegraph message boy at Watertown, N. Y., thus early entering the field which, in its subsequent expansion, was to become the scene of his life work, if that term can fairly be applied to the career of a man still four years under fifty. From this period he was dependent upon his own resources for his support and for his future. While in the Watertown office he learned to be a telegraph operator, by which vocation he afterwards maintained himself while pursuing college studies. In 1859 he went to Rochester, N. Y., entering the university of that city, where he completed one year's course and part of the next, supporting himself by night service in the telegraph office, where his duties consisted, for the most part—to use his own words—"in reporting himself awake every fifteen minutes." In 1862 he went to New York, where he worked as an operator, and at the same time completed his sophomore college year at the New York University.

In his twenty-second year Mr. Barton returned to Rochester, relinquishing a further college course, and henceforth devoting himself to work and business. He resumed work as an operator, and during his four or five years in Rochester made some not very successful ventures in Western Union stock. There was little if any encouragement for telegraphers at this period; salaries were gradually but steadily reduced, and in the autumn of 1868 Mr. Barton went into the business of electrical manufacturing with Mr. George Shawk, at Cleveland, Ohio. Subsequently, Mr. Elisha Gray bought Shawk's interest, and in 1870 the firm of Gray & Barton moved their business to Chicago, where it soon acquired importance, and became the nucleus upon which the business of the Western Electric Manufacturing Co. was founded in 1872. In the Cleveland days Mr. Barton was bookkeeper, shipping clerk, salesman, cashier and business manager, his partners looking after the workshop.

In the spring of 1872 the business of Gray & Barton was consolidated with that of the Western Union Telegraph Co.'s shop, at Ottawa, Ill., and both were merged in the Western Electric

Manufacturing Co., with a capital stock of $150,000. The late General Anson Stager was president of the new company, Mr. Barton was secretary, and Mr. Gray superintendent of the shop.

A factory was built on Kinzie street, Chicago, to which the Ottawa shop was removed, and in which the company continued its work for some years. The managers of the company took for their field of operations the whole range of electrical applications, and beginning with little else than telegraphic machinery and supplies, rapidly and steadily added new branches of work, until now its business includes nearly everything electric that can be named, from a push-button and box-bell to an electric light installation.

In April, 1879, The Western Electric Manufacturing Co. acquired the shops of the Western Union Telegraph Co. at New York, and increased its capital stock to $300,000.

In 1881 the Western Electric Co., with a capital stock of $1,000,000 was organized to succeed to the business of the Western Electric Manufacturing Co., and at the same time the business of Charles Williams, Jr., of Boston, Mass., and of the Gilliland Electric Manufacturing Co., of Indianapolis, was absorbed by the new company. About the same time the Bell Telephone Manufacturing Co., of Antwerp, was organized as a branch of the Western Electric Co., under the managership of Mr. F. R. Welles, and a little later an office and salesroom in London was opened by the Western Electric Co. During the present year the business of the Standard Electrical Works has been taken over by the Western Electric Co.

The business of the Chicago factory was moved in 1883 to the present extensive and well-appointed building in South Clinton street. The company is now erecting a large and commodious factory at the corner of Thames and Greenwich streets, New York city.

During the entire sixteen years of its history Mr. Barton, in the offices of secretary, vice-president and general manager, and president of the Western Electric Co. and its predecessor, has been its active executive officer. Together with General Stager, whose abiding faith in the policy of combination, and skill in carrying it out, were so striking a feature of his official relations with telegraph and other corporations, he planned and brought about the series of consolidations and acquisitions that have placed the present company in its commanding position in relation to nearly all branches of electrical work. Mr. Barton possesses, in an eminent degree, the stable qualities of foresight, firmness and patience. Like most strong men he has an abundant sense of humor, and not seldom answers a question, or conveys his views or instructions to his associates or subordinates, by telling a pointed story or making an apt quotation, which is sure to be amusing or edifying, and is usually both.

After the death of General Stager in 1885, Mr. Wm. S. Smoot was elected president of the Western Electric Co., and after his death, early in the following year, Mr. Barton was elected president.

H. M. BYLLESBY.

VICE-PRESIDENT AND GENERAL MANAGER, WESTINGHOUSE ELECTRIC CO.

MR. BYLLESBY'S career, and the prominent and responsible position already achieved by him, constitute a signal illustration of the relatively early age at which most of the men prominent in the development of the more recent applications of electricity to useful arts have accomplished important work and attained general reputation.

Mr. Byllesby is still less than thirty years old, having been born in 1859. He received his education at Lehigh University, Bethlehem, Pa. Mechanical engineering was the pursuit he set before himself, and soon after leaving college he entered the Corliss Engine Works, where he spent four years in congenial work and in acquiring a comprehensive practical acquaintance with the designing and construction of machinery.

To a well trained mechanical engineer the rapid growth of electro-mechanics, which followed the successful introduction of electric lighting as a commercial industry, could not fail to be an attractive field of activity, and in 1878 Mr. Byllesby entered it. He spent a year with Mr. Edward Weston, in association with whom it is needless to say he found opportunity to acquire an extensive knowledge, both theoretical and practical, of dynamic electricity and its related arts.

Mr. Byllesby next entered the service of the Edison Electric Light Company, and remained with them some five years, finding, in their widely and rapidly expanding business, opportunity and occasion to become further familiar with both the technical and commercial features of the industry.

After leaving the service of the Edison company, Mr. Byllesby for some time engaged in electric lighting business on his own account, making and executing contracts for installation.

Upon the formation of the Westinghouse Electric Company in 1885, Mr. Byllesby was engaged by that company to take a prominent part in the promotion of its venture into the electric field. He threw himself into the work with such energy and efficiency as to bring himself rapidly to the front, and within a year from his engagement was made general manager of the company. Three months after this appointment he was elected vice-president, which office he still holds, together with that of general manager.

Mr. Byllesby's clean-cut, energetic manner of transacting business, together with his extensive knowledge of the technical part of the electric lighting industry, and his inventive talent, have unquestionably contributed largely to the remarkable growth of the business of the Westinghouse company.

RONALD T. McDONALD.

TREASURER AND GENERAL MANAGER, FORT WAYNE JENNEY ELECTRIC LIGHT CO.

THE vigorous and aggressive qualities characteristic of the management of the Fort Wayne Jenney Electric Light Co. are easily discerned in the countenance of Mr. McDonald, its treasurer and general manager.

Mr. McDonald was one of the incorporators of that company in 1882, and became at once a director, assuming at the same time the conduct of its business as an executive officer.

Mr. McDonald has not yet reached his fortieth year. He is a native of Pennsylvania, and was born in Allegheny City in 1849. He entered the army as a drummer boy during the War of the Rebellion, and became a soldier before its close. He had no academic education, never having gone beyond the common schools of his home.

He began his business life in the dry goods trade, and at an early age became a member of the firm of Evans & McDonald, at Fort Wayne, Ind., wholesale dealers and jobbers in dry goods.

Mr. McDonald left the dry goods trade to take up the wholly unrelated business of electric lighting; took a prominent part in organizing the Fort Wayne Jenney company; became at once the manager of its business, and still continues as its leading spirit in the enterprising and successful operations of that company.

Quick perception and prompt action, alertness in observation and movement, characterize Mr. McDonald's administration of the business of his company. Competition is the proper field of action for such energetic and combative natures, and Mr. McDonald's success in building up a widely extended business in electric lighting, an industry which, at the time of starting the Fort Wayne Jenney company, had already become securely established, and was in the hands of a few strong companies, sufficiently attests his fitness for the initiation and maintenance of a competitive business, against well-established and fortified opposition.

The Fort Wayne Jenney, under his management, has become one of the leading arc light companies, and is rapidly gaining a foothold in incandescent lighting.

ARTICLES.

SHALLENBERGER'S ELECTRIC METER.

Some months ago, a new application of the alternating current in the production of rotary motion was made known almost simultaneously by two experimenters, Nikola Tesla and Galileo Ferraris, and the subject has attracted general attention from the fact that no commutator or connection of any kind with the armature was required. The principle has been very successfully applied by Mr. Tesla in the production of a practicable motor, which is destined soon to occupy an important place among the growing number of electrical appliances depending upon alternating currents for their operation.

For some time previous to the publication of the results above referred to, Mr. O. B. Shallenberger, electrician of the Westinghouse Electric Co. had been at work on a series of experiments tending in the same direction, the results of which served as a basis for the construction of a meter depending on analogous principles, something that could be made and used in a rough and ready way, without diminishing its reliability.

This, it is thought, has now been accomplished, although the use of the instrument in its present form is limited to alternating currents. In this connection it may be observed that although a few years ago one of the objections raised against the use of alternating currents was the difficulty in measuring them in a practical way, the fact is that these difficulties have gradually disappeared, until they are less important than in the use of direct currents.

The principle upon which the new meter operates may be understood from the following considerations. If an alternating current be made to traverse a coiled conductor in proximity to two other conductors closed upon themselves, the secondary currents set up in these two conductors will correspond with each other to a greater or less extent in phase, and will be approximately in the same direction at the same instant, but both will differ in phase from the primary or inducing current. An attraction consequently takes place between the two secondary circuits, and if free to move the conductors carrying these currents will be attracted to each other in a greater or less degree

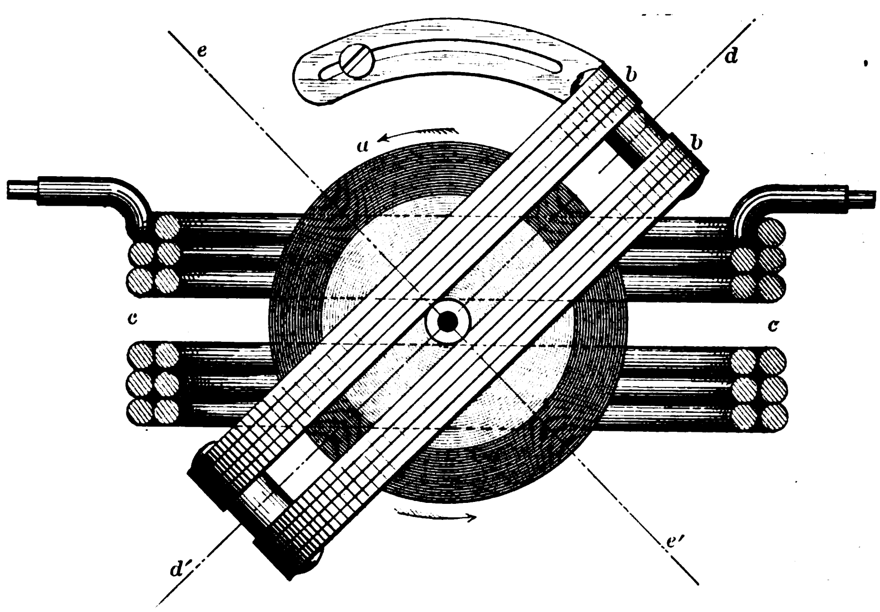


Figure 1.

although applied in a way differing notably from anything described up to the present time by either of the investigators referred to. The meter was already completed in an experimental form at the time when the results of the experiments of Mr. Tesla and Mr. Ferraris were made known, and its thorough practicability was demonstrated, although for legal reasons it was unadvisable to make the fact known at that date.

Notwithstanding the urgent need of a meter wherever electric lighting has been carried on commercially, nothing has presented itself thus far that indicated any decided advance in this direction, until the advent of the instrument invented by Professor Forbes, the great simplicity and beauty of which cannot be gainsaid. The one apparent difficulty in the way of its adoption seems to be its extreme delicacy and the necessarily minute accuracy in its manufacture and adjustment required to obtain satisfactory results.

It has been the desire of Mr. Shallenberger to produce a meter equally simple, but, if possible, more practicable in its nature, and requiring a less degree of skill on the part of the workmen in manufacturing; or in other words, depending on the amount of the primary current and on the displacement of phase between the primary and secondary currents. If one of these conductors be made fixed and the other movable, the motion will evidently be confined to one of the conductors, and if the action can be continued so as to produce the attraction always in the same direction, a continuous, rotary motion may be obtained by the inductive action solely, and without any direct communication with the source of current. The discovery of this principle suggested at once the practicability of applying it to the operation of a meter since it is only necessary to produce a rotary effort or torque in some simple and reliable way, bearing a definite relation to the current that produces it, in order to have a perfectly accurate means for measuring such current.

With this end in view a number of experiments were made which it is unnecessary to follow here, presenting a great variety of effects depending in a general way upon the principle referred to, and leading eventually to the form of meter here described.

It was found that one of the conductors might be replaced by a core of iron, inasmuch as the mutual

attraction between the iron core and the coil could be made to serve in place of the attraction between the two secondary coils, and with greater effect so long as proper relations were maintained to carry out the same mode of operation. If a disc of iron be surrounded by a copper band and this with another conductor at an inclination to the first, the passage of a current through the outer coil

b b are copper plates punched in the form of a flattened oval and riveted together at the ends, placed so as to surround the disc closely without touching it. These are adjustable in position with respect to the coil *c c*, which surrounds the whole. When in the position shown the rotation of the disc is in the direction of the arrows, and the torque is greatest when the plane of the coil shown by

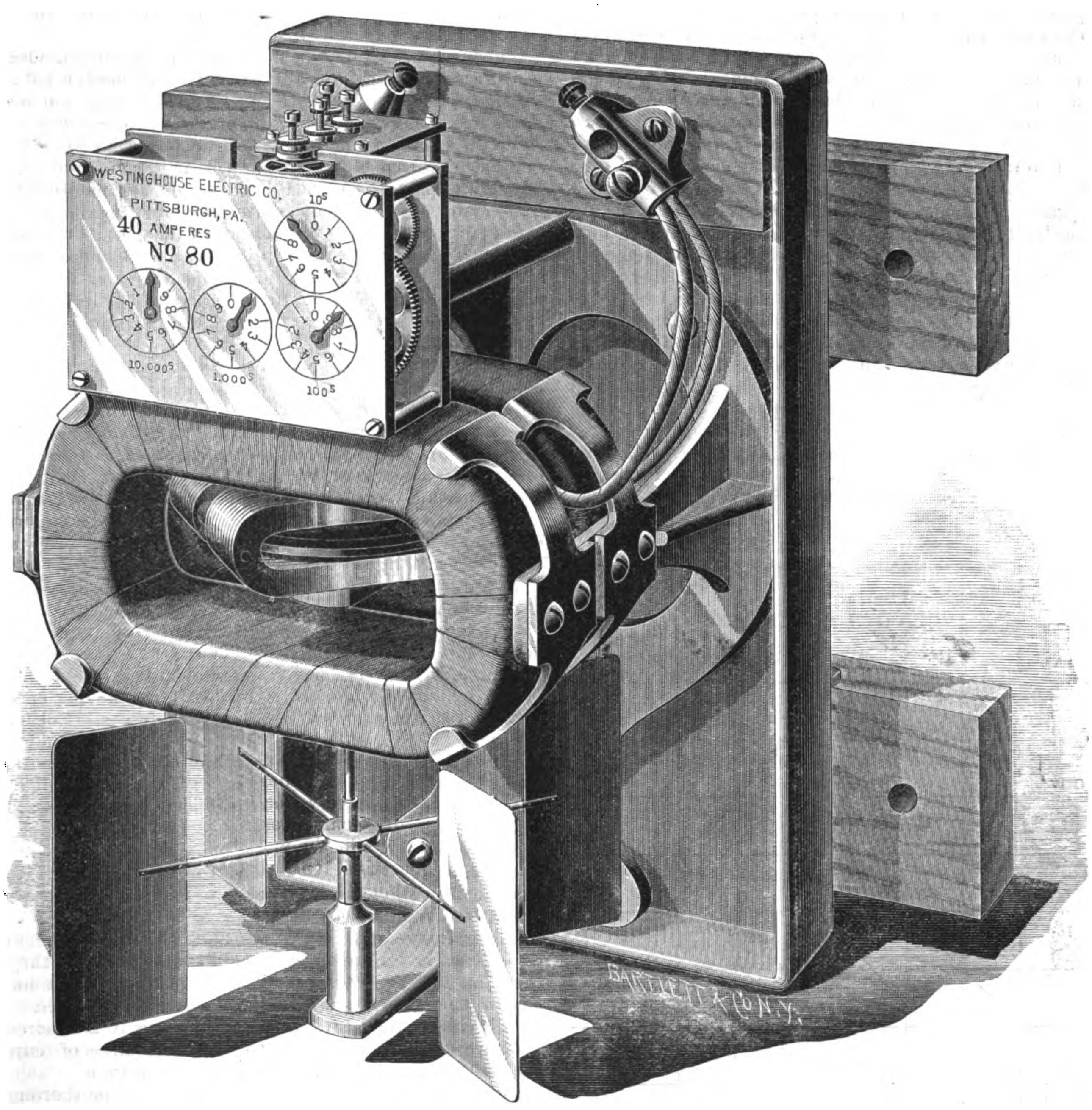


FIGURE 2.—Shallenberger's Meter (case removed).

will, by the action of the secondary currents set up in the short-circuited coil, produce a rotation of the disc; and the torque exerted is approximately proportional to the square of the current, so long as the rate of alternation is maintained approximately constant.

Referring to the diagram, figure 1, *a* is a flat ring of soft wrought iron mounted on a light disc of brass or aluminum, rigidly attached to a slender steel shaft.

the line *d d'* is at an angle of 45° to that of the coil *c c* If while the current is passing through the coil the position of the plates *b b* is changed gradually to *e e'*, the speed of rotation of the disc diminishes until an angle of 90° is reached, and beyond this the direction of rotation reverses, reaching maximum speed again at 45° on the opposite side.

In applying this to the meter only a few degrees move-

ment of the secondary conductors *b b* is required for the necessary adjustment.

This arrangement was selected from a large number of others because of its ease of construction, the small self-induction it introduces, and its ease of adjustment.

The maximum torque is exhibited at an angle between the coils of 45°, while at 0° and 90° it disappears altogether. When the angle is 0° the coils being parallel have a maximum mutual induction, but no torque is exerted; and at 90° no current is induced in the secondary coil, and consequently there can be no torque in that position.

In order that the speed of the disc may be proportional to the current it is necessary that some resistance be offered to its motion, which bears the same relation to the speed as that of the torque to the current, and the simplest means of doing this is to attach to the same shaft on which the disc is carried a suitable number of light vanes, whose motion is opposed by the resistance of the air as the disc revolves. This resistance is found to vary almost exactly in the proper ratio, and consequently the revolution of the disc is as nearly as possible proportional to the strength of the current. The rotations of the disc are counted by a train of wheels connected with an indicator similar to that used for gas meters, and showing ampere hours. The accuracy of the instrument is affected slightly by changes in the rate of alternation of the current; but since in practical electric lighting the rate of alternation is maintained nearly constant, the error due to this cause is quite insignificant, being less than proportional to the number of alternations. The adjustment to the exact speed required is made by changing the angle of the secondary coil; but in practice the instrument is made very nearly correct as it leaves the factory, requiring only slight correction.

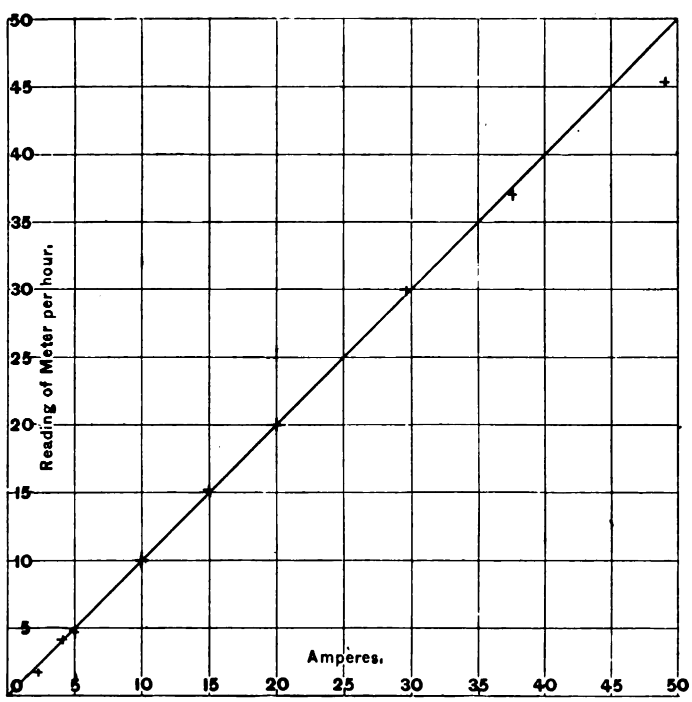


FIGURE 3.—Test of Shallenberger's Meter.

TEST OF 40 AMPERE METER.

Current in amperes.	Reading of meter.	Percentage of error.
2.06	1.6	
4.02	4.07	+1.2
5.00	4.95	—1.0
9.9	10.02	+1.2
15.0	15.1	+0.7
20.0	20.0	0.0
29.7	30.0	+1.0
37.4	37.0	—1.1
	Overloaded	
49.3	45.4	—7.9

The accompanying chart and table show the operation of a 40 ampere meter, with currents varying from the smallest capable of turning the vanes and overcoming the slight friction of the bearings, to an overload of 25 per cent. Currents are measured on the horizontal line, and the corresponding readings of the meter are shown by the vertical distances. It will be seen that the departure from the theoretical straight line representing the mean performance of the meter is very slight, and in no case within the working limits reaches two per cent., except at starting point; while at 25 per cent. overload, the proportional rate only falls off 7.9 per cent.

The ease with which this meter may be adapted to circuits of different capacity is obvious. By interposing between the meter and the circuit to be measured a small converter, the current may be reduced or increased in any ratio, and since the energy transformed by such converter is only the amount required in operating the meter, namely, about one-eighth of one per cent. of the energy measured, the dimensions of the converter may be very small, and consequently but very little is added to the cost of the simple meter. By changing the ratio of this converter any capacity may be given to the meter, so that the same instrument may be used to measure 10 lights or 10,000 lights within the same percentage of accuracy and without change in its construction.

There is, however, one feature worthy of notice in this connection, namely, the point at which the meter will begin to turn, or in other words, the percentage of its full load at which the registering of the current begins. This, in the 40 ampere meter already mentioned, is 1½ amperes, or say three per cent. of the rated capacity. While this represents only one or two lamps on a 40 ampere meter, and only one lamp on a 20 ampere meter, it will be seen at once that on a meter for 1,000 lamps the same proportion would give 30 lights required to start the counter.

In order to overcome this difficulty for the larger sizes of meters a shunt coil is provided, which, with a current almost inappreciable in amount, charges the inducing coil of the meter to a degree sufficient barely to overcome the inertia and friction of the vanes, and in this way the large meter may be made to start on less than one per cent. of its full load as easily as the small meters start on three per cent.

There are certain cases in which it is very desirable, even where a large number of lights are installed, to measure a comparatively small proportion of the total current. Lamps are sometimes used for watch lights and other purposes, while the main body of the lamps are or are not in operation, and it is for this reason that the shunt coil is applied. Its operation may be made as sensitive as the conditions require.

The greater simplicity of the meter having a direct coil only, both in its construction and connection in the circuits, makes it preferable not to employ the shunt coil on any of the smaller sizes, namely, below 40 amperes. But it is evident that in special cases where it is desired to measure accurately the widest possible range of current the shunt coil can be employed with advantage.

Practical tests have shown this meter to be thoroughly reliable in its action, and with the exception of some minor details in the construction, no serious difficulties have presented themselves at any time. The meter as now manufactured for practical use seems to fill the requirements very satisfactorily, and has given no cause to doubt its entire reliability within limits of error much smaller than have hitherto been obtained in ammeters, voltmeters, and similar instruments.

. . . Now let it be proposed to put underground all the tens of thousands of wires in the city (New York), telegraph, telephone and electric light, in close proximity as they must be, in many cases, and I think the problem would appear appalling to any one except a commissioner or newspaper reporter who knew nothing about it.—*Professor Wm. A. Anthony*

DISCUSSION OF THE PRECISION OF MEASUREMENTS.[1]

BY SILAS W. HOLMAN, S. B.

Associate Professor of Physics, Massachusetts Institute of Technology.

(Concluded from page 300.)

$m_3 = r, \delta r = 0.001 r = 00.2$ cm. Direct measurement of the diameter $2r$ by a steel scale, correct within 0.1 mm., may be made at many diameters. This is liable to errors from irregular thickness of insulation (causing uncertainty as to position of wire), from irregular winding, and from ellipticity of coils. An AD for r as small as 0.02 cm. may be obtained on a good coil by careful work. It is usually better to measure the outer circumference of the coil by a steel tape, and the average thickness of the coil, and thence to compute r; or, better still, to measure the circumference of each layer as it is wound. A circumference measurement to $AD = 0.01$ cm. would give $\delta r = \frac{0.01}{6.3}$ cm., since circumference $= 2\pi r$. Sometimes the length of the wire to compose the coil is measured before winding, and r computed from this length and n. But liability to stretch renders this result unreliable except with heavy wire wound and measured with great care.

$m_4 = n$. This is necessarily a whole number, and unless $n = 1000$ or more, cannot be in error by one turn without producing a greater effect than

$$\frac{\delta C}{C} = 0.001.$$

$m_5 = \tan\varphi \therefore \delta m_5 = \delta \tan\varphi = 0.001 \tan\varphi$. Since $\tan\varphi$ is a variable, we must study its δ as a fraction of φ. $\frac{d(\tan\varphi)}{d\varphi} = \sec^2\varphi \therefore \frac{\delta\tan\varphi}{\tan\varphi} = \frac{2\,\delta\varphi}{\sin 2\varphi}$. Several important points deducible from this expression will be given later. $\frac{\delta\tan\varphi}{\tan\varphi}$ is a minimum for $\varphi = 45°$, as will be seen by inspection. This value only will be considered here. For this, $\frac{\delta\tan\varphi}{\tan\varphi} = \frac{\delta C}{C} = 0.001$, $\delta\varphi = 0.001$, $\frac{\sin 2\times 45°}{2} = 0.0005$. The arc whose length is radius is 57°.3 appr. $\therefore \delta\varphi° = 0.0005 \times 57. = 0°.03$ about. The galvanometer considered is read to 0°.1 by eye estimation of tenths of degree. It is assumed that in a single estimation the maximum error will be $\frac{1}{10}$ degree. A value of φ is the mean of four readings. The case falls under the first special law of deviations. Therefore, the $a\ d$ of single estimation $= \frac{0.05}{2} = 0.025$, and for the mean of the four readings, $\delta' = \frac{0.025}{\sqrt{4}} = 0°.013$. Thus the errors of stimation in reading $\varphi =$ less than $\frac{1}{2}$ the δ prescribed. But there are also errors in φ from eccentricity (eliminated by averaging), irregular graduation, inclination of mirror and graduated circle to horizontal, inclination of plane of coils from vertical, and displacement of plane of coils from magnetic meridian. Irregularity of graduation must be separately studied and corrected, though the averaging of four readings reduces its effect. The other sources of error mentioned will be discussed later, and it will be shown that with care they can be rendered negligible in effect. The combined errors of estimation and graduation may easily fall within $\delta\varphi = °0.03$.

In discussing the correction terms we may desire to know: 1st, Values of δ's to make the correction term either of a given effect, $\frac{\delta C}{C}$, or negligible so that it may be omitted. 2d, Values of the magnitude of the quantities entering into the correction which will make its effect either of a given amount, or zero, or negligible.

The correction terms are all factors of the form $m = (1 + A)$ when A is a function of one or more quantities, x, y, etc., and is small, relatively, to unity. Hence,

$$\frac{dm}{dx} = \frac{d(1+A)}{dx} = \frac{dA}{dx} \therefore \delta m = \delta A,$$

and as $m = 1$ (sensibly),

$$\frac{\delta m}{m} = \frac{\delta A}{1} = \delta A.$$

Thus, for $\frac{\delta m}{m} = 0.001$, $\delta A = 0.001$, and for $\frac{\delta m}{m} < 0.0001$; *i. e.*, negligible, $\delta A < 0.0001$.

$m_6 = \left(1 + \frac{1}{2}\cdot\frac{b^2}{r^2} - \frac{1}{3}\cdot\frac{d^2}{r^2}\right)$ is the correct factor for dimensions of coil-section, when $2b$ and $2d$ do not exceed 0.1, or, better, 0.05 of r. Consider first values of δ's which, with the given magnitudes of $2b$ and $2d$, will make $\frac{\delta m_6}{m_6}$ negligible; *i. e.*, less than $\frac{1}{10} \times 0.001$. We must then have $\delta A = \delta\left(\frac{1}{2}\cdot\frac{b^2}{r^2} - \frac{1}{3}\cdot\frac{d^2}{r^2}\right) < 0.001$. As r must be determined more closely for use in m_3 than for this correction, δr may be here disregarded. Applying XXII. for equal effects of δ's, we have

$$\Delta = 0.0001,\ n = 2, \therefore \frac{\Delta}{\sqrt{n}} = 0.0007.$$

$\frac{dA}{db} = \frac{b}{r^2}$, $\frac{dA}{dd} = -\frac{2}{3}\cdot\frac{d}{r^2}$, or as $2b$ and $2d$ are the measured quantities,

$$\frac{dA}{d2b} = \frac{b}{2r^2},\ \frac{dA}{d2d} = -\frac{1}{3}\cdot\frac{d}{r^2}, \therefore \delta 2b = \frac{\Delta}{\sqrt{n}} \Big/ \frac{dA}{d2b}$$
$$= 0.06 \text{ cm.},\ \delta 2d = 0.07 \text{ cm.}$$

Of course we might similarly compute the values of $\delta 2b$ and $\delta 2d$ for $\frac{\delta C}{C} = 0.001$, but this is unnecessary, as it is obvious that the narrower limit just computed can be attained, and thus the correction rendered sensibly exact.

For magnitudes of b and d. The correction will be negligible when $A < 0.0001$. Inspection shows that A is zero when $\frac{1}{2}\cdot\frac{b^2}{r^2} = \frac{1}{3}\cdot\frac{d^2}{r^2}$; *i. e.*, $\frac{b^2}{d^2} = \frac{2}{3}$, or $\frac{b}{d} = \frac{4}{5}$ approx.

For the given galvanometer it is only necessary then to have these proportions exact within $\delta 2b = 0.06$ cm., and $\delta 2d = 0.07$ cm., in order to have the correction vanish. It is obvious that this proportion of $b : d$ may be considerably departed from without loss of accuracy, if only the correction be carefully determined and applied. It should, however, be borne in mind that the form of the correction assumes a uniform distribution of wires in the coil-section.

$m_7 = \left(1 - \frac{3}{4}\cdot\frac{l^2}{r^2} + \frac{15}{4}\cdot\frac{l^2}{r^2}\sin^2\varphi\right)$ is the correction factor for length of needle when $2l$ does not exceed 0.1 to 0.05 of r. As in m_6 we may consider r as exact. A similar statement applies to φ. We have, therefore, to deal only with

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$\delta\, 2\, l$. Consider first values of $\delta\, 2\, l$, which, with the given magnitude of $2\, l$, will render

$\frac{\delta m_7}{m_7}$ negligible ; *i. e.*, < 0.0001. As A contains φ, which, though exact, is not constant, it should be studied for all values of φ. But for its best work the galvanometer will be used only between $\varphi = 30°$ and $60°$, and it will be shown that A increases from $\varphi = 26°.6$ upward. Hence it will suffice to compute for the worst case. Substituting then

$\varphi = 60°$, we find $A = 2\,\frac{l^2}{r^2}$ nearly.

$$\therefore \frac{d\,A}{d\,l} = \frac{4\,l}{r^2}, \therefore \delta\, l = \frac{r^2}{4\,l}.\ \delta\, A, \therefore \delta\, 2\, l = \frac{r^2}{2\, l}\,\delta\, A = 0.04 \text{ cm.},$$

which is easily attainable. Note that $2\, l$ is the distance between the magnetic poles of the needle, which is about 0.85 of the whole length if the needle is a straight, thin prism.

The correction will vanish when $\frac{3}{4}.\ \frac{l^2}{r^2} = \frac{15}{4}.\ \frac{l^2}{r^2}.\ \sin^2\ \varphi$.

Solving this for φ gives $\varphi = 26°.6$. Hence the correction vanishes whatever the length $2\, l$ (within limit $0.1r$), when the deflection is $26°.6$. For the given galvanometer the correction cannot be disregarded nor rendered negligible between $30°$ and $60°$, because 1 cm. is about as small as $2\, l$ can be made without introducing too great torsion correction, and $\delta\, 2\, l$ cannot be reduced much below 0.04 cm.

$m_8 = \left(1 + \frac{\varphi\,\Theta}{\sin\ \varphi}\right)$ is the correction factor for torsion when this is not unduly great. This does not take account of initial torsion, which is in part eliminated by reading reverse deflections. In this factor φ may be regarded as exact, for reasons similar to those given for r and φ in m_7 and m_6. But though exact, φ varies. Inspection shows that as φ increases more rapidly than its sine, the value of m_8 increases up to $\varphi = 90°$. Hence, for reasons similar to those given under m_7 in a similar case, we may consider only $\varphi = 60°$. Substituting this value gives $A = 70.\ \Theta$ nearly. To find value of $\delta\ \Theta$ to make $\frac{\delta\, m_8}{m_8}$ negligible, *i. e.*, $\delta\, A < 0.0001$, we have

$$\frac{d\,A}{d\,\Theta} = 70, \therefore \delta\ \Theta = \frac{0.0001}{70} = 0.00\,000\,14.$$

To ascertain whether this is attainable in the given instrument, we must know how closely Θ may be found in it. With the needle strongly magnetized and suspended by a single fine fibre, Θ may be as small as 0.00 005, or even 0.00 001, and may be determined within ten per cent. of its value ; *i. e.*, with $\delta\ \Theta = 0.00\,000\,5$ to $0.00\,000\,1$. Hence, torsion factor in such case may be determined with such closeness that $\frac{\delta\, m_8}{m_8}$ is negligible, but the correction must be applied in this grade of work.

$m_9 = \left(1 + \frac{3}{2}\,\frac{x^2 + y^2 - 2z^2}{r^2}\right)$ is the correction factor which serves to correct for the displacement of the centre of the needle from the centre of the galvanometer coil, x and y being the rectangular components of this displacement in the plane of the coils, and z the component perpendicular to that plane, x, y and z being small in proportion to r. By inspection, therefore, it appears that along any surface whose equation is $x^2 + y^2 - 2\, z^2 = 0$ the correction would disappear. If a limiting value, a, be assigned to x, y and z, each, the correction will be a maximum when $z = 0$ and $x = y = a$, or when $x = y = 0$, and $z = a$. As all values between 0 and a will occur, the correction term may have any value from 1 to $1 \pm 3\,\frac{a^2}{r^2}$. The law of distribution of the errors will be a special one, but will not differ widely from the general one. Hence the $a\, d$ may be assumed as about $\frac{3}{4}.\ \frac{a^2}{r^2}$. See paragraph on Estimated Precision Measures, p. 198]. In order, then, that m_9 be negligible, we may write

$$\frac{3}{4}.\ \frac{a^2}{r^2} < \frac{1}{10} \times 0.001 = 0.0001 \therefore a^2 < 0.0001\,\frac{4 \times 400}{3} = 0.05$$

cm. $\therefore a < 0.22$ cm. That is, the centre of the needle should be within a radius (on the average) of less than about $\frac{1}{4}$ cm., which is easily possible.

m_{10} is the correction factor for the inclination of the circle to the horizontal, which would, of course, introduce error into φ. The graduated circle is assumed to be rigidly attached to the mirror. Suppose the circle and mirror inclined by an angle h to the horizontal. The line of sight is always normal to the mirror. Imagine a right circular cylinder erected with the graduated circle as a base. Then the accompanying figures will represent projections of this cylinder. E''', F''', will be the projection of the circle upon a vertical plane. $G\ I$ will be another projection of the circle upon a plane at right angles to the former and parallel to the axis of the cylinder,—which, of course, is the direction of sight in reading. $E'\ A'\ F'\ I'$ is the projection of the circle on a plane parallel to itself, and, therefore, shows the circle in its true dimensions, as it is always seen, because the lines of projection are here the lines of sight. The *horizontal* plane swept through by the index would be then that indicated by $A\ B\ E\ K—A''\ D''\ E''$, making an angle h with the plane of the circle. This plane will intersect the cylinder in an ellipse $A\ B\ E\ K—A''\ D''\ E''—A'\ B'\ E'\ I'\ F'$.

1°. Let A, A', A'' be the zero point of the circle and index. Let the needle be deflected to the position D'', B, B'. The real angle of deflection φ of the needle in the horizontal plane will be represented in the diagram only by its projections, $A\ C\ B—A'\ C'\ B'$. The observed angle is $\varphi = A'\ C'\ B'$, which is, of course, the projection of φ upon the base of the cylinder. We must find some equation connecting φ and φ'. Pass a plane tangent to the cylinder along the element $A\ G—A'$. Its trace in the plane of the circle will be $M'\ A'\ D'$. Prolong $C'\ B'$ until it intersects $M'\ A'$ at D', and locate on the other projections the corresponding points D'', D'''. Then $\tan\,\varphi' = \frac{A''\ D''}{r}$ when $r = A\ C = A'\ C' = E'\ C' =$ radius of circle. Also, $\tan\,\varphi = \frac{A'D'}{r} = \frac{A'''\ D'''}{r}$. Hence $\frac{\tan\,\varphi'}{\tan\,\varphi} = \frac{A'''\ D'''}{A''\ D''} = \cos\ h \therefore$ $\tan\,\varphi = \frac{\tan\,\varphi'}{\cos\,h}$, and we may write $C = \frac{10\,H}{G}\,\frac{\tan\,\varphi'}{\cos\,h}$.

The effect of inclining the mirror *in this case* is thus the same as inclining the coils in the cosine galvanometer.

2°. If the angles be measured from E, E', E'' as zero position, then $\tan\,\varphi = \tan\,J\ C\ E$ revolved $= \frac{J\,E}{A''\,E''}$; $\tan\,\varphi' = \tan J'\ C'\ E' = \frac{J'\,E'}{r} = \frac{J\,E}{r} \therefore \frac{\tan\,\varphi'}{\tan\,\varphi} = \frac{A''\ E'}{r}$ $= \frac{A''\ E''}{E''\ L} = \frac{1}{\cos\,h} \therefore \tan\,\varphi = \tan\,\varphi'\,\cos\,h.$

3°. If the zero line be neither $A\ C$ nor $E\ C$ then the correction will be unsymmetrical, but, as it will not in any case differ widely from the above values, it is unnecessary to discuss the general expression.

It may be seen by inspection that the reading of both ends, and of reversed currents, will not affect this error. In the demonstration it has also been assumed that the projections of the centre of the needle was upon the centre of the circle. If this is not the case a variable eccentricity will be introduced, which will be eliminated by the ordinary method of reading both ends of the needle.

In order that the error from h may be negligible, we must have $\frac{\tan\varphi - \tan\varphi'}{\tan\varphi} \overset{=}{<} 0.0001$. From equation in 1° case $\frac{\tan\varphi - \tan\varphi'}{\tan\varphi} = \frac{1-\cos h}{1}$, and in 2° case $= \frac{\cos h - 1}{\cos h}$, which, for small values of h, $= \frac{\cos h - 1}{1}$ appr. Thus for small values of h the difference in the two cases is merely one of sign. To be negligible we have, then, $\cos h = 1 - 0.0001 = 0.9999$; whence $h < 0°.8$, which would require care in original adjustment of plane of mirror to horizontal, and corresponding care in subsequent leveling of galvanometer.

m_{11} is the correction term for ellipticity, or irregularity of coils. The strength of field at the needle due to unit current in the coils might be found by integration. This will increase in intensity as the coil becomes more elliptical. But the value of the integral will change slowly with small eccentricity of the ellipse; and as it is easy to keep the difference between the major and minor axes within limits of a fraction of a millimeter, it seems that the error may be considered as then negligible—though always tending to produce a + error in C as computed on the supposition of a circular coil. Irregular winding of the coils tends to produce a similar effect.

m_{12} is the correction factor for plane of coils not being vertical. Let v be the angle by which the plane is inclined to the vertical. The effective part of the field G is then its horizontal component only, viz., $G \cos v$. This error will, therefore, be negligible, similarly to m_{10} when $1 - \cos v < 0.0001$, or $v < 0°.8$ about.

m_{13} is the correction factor for plane of coils being out of magnetic meridian. If it is so, the field F at the centre, due to the current, is oblique to H and $\varphi_1 >$ or $< \varphi_2$, *i. e.*, the deflections on opposite sides of the zero are unequal. In figure 1 the plane of the coils is inclined by w to the west of north, *i. e.*, by a — angle. The deflection usually employed is $\frac{1}{2}(\varphi_1 + \varphi_2)$, these being *the angles swept through by the pointer* in passing from its normal position when the *needle* is in the meridian to that when the needle is successively in the directions of the resultant fields with reversed currents. Of course corrections may be made for error of index from zero of scale when at normal position, but no advantage is thus gained. The error m^{13} may be eliminated by turning the coils by trial until, when corrected for initial position of pointer, $\varphi_1 = \varphi_2$; but exact adjustment is

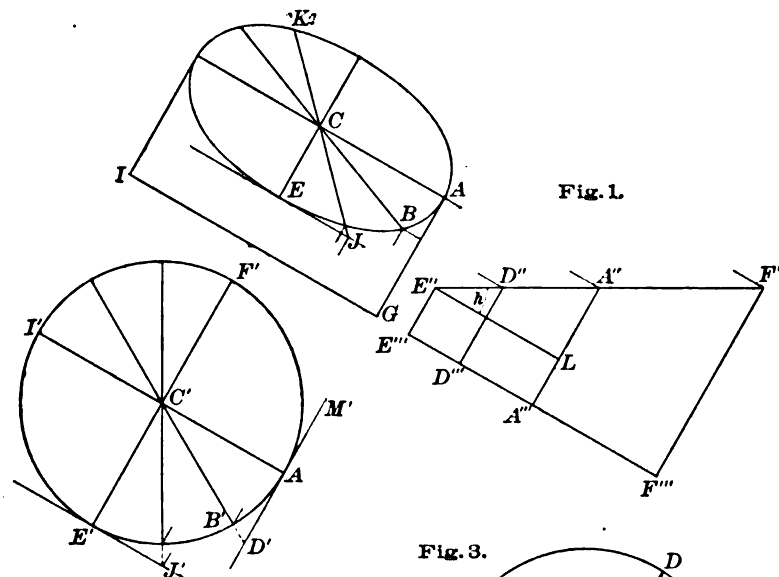


Fig. 1.

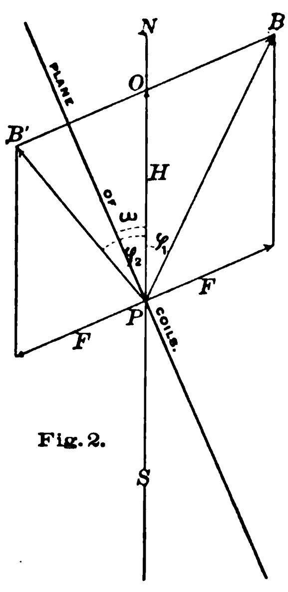


Fig. 2.

Fig. 3.

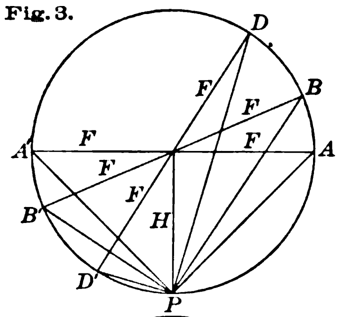
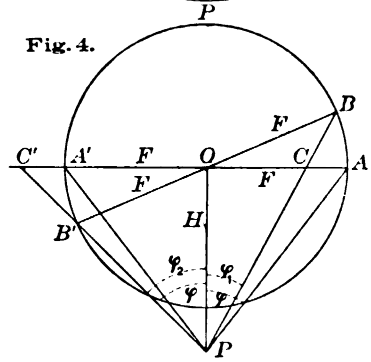


Fig. 4.



troublesome, and it is, therefore, necessary to know the best process, and how small it is necessary to make w in order that it may be negligible.

In the figures, F is the field due to the current in the coils; w = angle between plane of coils and meridian; φ = the true angle of deflection; φ_1 and φ_2 = the observed deflections with reversed currents. Figures 2 and 4 show the constructions to find, by triangle of forces, the direction and magnitude of the resultant fields PA, PA', PB, PB', etc, and thus the values of φ, φ_1 and φ_2. Figure 3 is the solution for the case when $F = H$, *i. e.*, where $\varphi = 45°$, where it appears that whatever the value of w [$= AOB$, or AOD, etc.] the value of $\varphi_1 + \varphi_2$ [$= BPB'$ or DPD', etc.] is always 90°, so that $\frac{1}{2}(\varphi_1 + \varphi_2)$ will be φ, the true deflection. This surprising result points very strongly to the use of deflections of about 45° when *accurate* values of C are sought. Figure 4 represents the general case, and from it the following demonstration gives the general expression connecting φ, $(\varphi_1 + \varphi_2)$, and w.

$$\text{In } OBP, \frac{OC}{OB} = \frac{\sin OBC}{\sin OCB} = \frac{\sin(90° + w + \varphi_1)}{\sin(90° + \varphi_1)}$$

$$= \frac{\cos(w + \varphi_1)}{\cos\varphi_1} = \frac{OC}{F}$$

$$\therefore \tan\varphi_1 = \frac{OC}{H} = \frac{F}{H}\cdot\frac{\cos(w+\varphi_1)}{\cos\varphi_1} = \tan\varphi\cdot\frac{\cos(w+\varphi_1)}{\cos\varphi_1}$$

$$= \tan\varphi\,[\cos w - \sin w\,.\,\tan\varphi_1] = \tan\varphi\cos w - \tan\varphi\,.\,\sin w\,.\,\tan\varphi_1$$

$$\tan\varphi_1 = \frac{\tan\varphi\,.\,\cos w}{1 + \tan\varphi\,.\,\sin w}.$$

$$\text{In } OB'P\ \frac{OC'}{OB} = \frac{\sin OB'C'}{\sin OB'B'} = \frac{\sin(90° - w + \varphi_2)}{\sin(90° - \varphi_2)}$$

$$= \frac{\cos(\varphi_2 - w)}{\cos\varphi_2} = \frac{OC'}{F}.$$

$$\therefore \tan\varphi_2 = \frac{OC'}{H} = \frac{F}{H}\cdot\frac{\cos(\varphi_2 - w)}{\cos\varphi_2} = \tan\varphi\cdot\frac{\cos(\varphi_2 - w)}{\cos\varphi_2}$$

$$= \tan\varphi\,[\cos w + \sin w\,.\,\tan\varphi_2] = \tan\varphi\cos w + \tan\varphi\,.\,\sin w\,.\,\tan\varphi_2.$$

$$\tan\varphi_2 = \frac{\tan\varphi\cos w}{1 - \tan\varphi\,.\,\sin w}$$

$$\tan(\varphi_1 + \varphi_2) = \frac{\tan\varphi_1 + \tan\varphi_2}{1 - \tan\varphi_1\,.\,\tan\varphi_2} = \frac{\dfrac{\tan\varphi\,.\,\cos w}{1 + \tan\varphi\,.\,\sin w} + \dfrac{\tan\varphi\cos w}{1 - \tan\varphi\sin w}}{1 - \dfrac{\tan^2\varphi\sin^2 w}{1 - \tan^2\varphi\sin^2 w}}$$

$$= \frac{2\tan\varphi\cos w}{1 - \tan^2\varphi} = \frac{2\tan\frac{1}{2}(\varphi_1 + \varphi_2)}{1 - \tan^2\frac{1}{2}(\varphi_1 + \varphi_2)};$$

$\therefore (1 - \tan^2\frac{1}{2}(\varphi_1 + \varphi_2))\tan\varphi\,.\,\cos w = (1 - \tan^2\varphi)\tan\frac{1}{2}(\varphi_1 + \varphi_2)$; $\therefore \tan\varphi\,.\,\cos w\,.\,\tan^2\frac{1}{2}(\varphi_1 + \varphi_2) + (1 - \tan^2\varphi)\tan\frac{1}{2}(\varphi_1 + \varphi_2) = \tan\varphi\cos w$; $\therefore \tan\frac{1}{2}(\varphi_1 + \varphi_2) =$

$$\frac{\tan^2\varphi - 1 \pm \sqrt{\{\tan^4\varphi - 2\tan^2\varphi + 1 + 4\tan^2\varphi\cos^2 w\}}}{2\tan\varphi\,.\,\cos w.}$$

The upper sign of the $\pm$ must be taken for the radical. For suppose $w = 0$, then $\sqrt{\{\text{etc.}\}} = \tan^2\varphi + 1$ and $\tan\frac{1}{2}(\varphi_1 + \varphi_2) = \frac{\tan^2\varphi - 1 \pm (\tan^2\varphi + 1)}{2\tan\varphi}$, which with the upper sign is $\tan\frac{1}{2}(\varphi_1 + \varphi_2) = \frac{2\tan^2\varphi}{\tan\varphi} = \tan\varphi$, which is, of course, the proper value, while that obtained by taking the lower sign would not be so. Hence

$$\tan\tfrac{1}{2}(\varphi_1 + \varphi_2) = \frac{\tan\frac{1}{2}(\varphi - 1 + \sqrt{\{\tan^4\varphi + 2\tan^2\varphi\,.\,\cos 2w + 1\}}}{2\tan\varphi\,.\,\cos w.}$$

For the case already solved geometrically, when $\varphi = 45°$.

$$\tan\tfrac{1}{2}(\varphi_1 + \varphi_2) = \frac{1 - 1 + \sqrt{(1 - 2 + 1 + 4\cos^2 w)}}{2\cos w} = \frac{2\cos w}{2\cos w} = 1.$$

For $\varphi = 90°$ (impossible on tangent galvanometer) $\tan\frac{1}{2}(\varphi_1 + \varphi_2) = \frac{\infty}{\infty}$ which is indeterminate in form.

The simplest way to study the effect of this error is to plot a series of values of $\frac{\delta C}{C}$, for various values of φ, obtained by computing $\tan\frac{1}{2}(\varphi_1 + \varphi_2)$ by the above equation for a series of small values of w. From such a plot made with values of $\frac{\delta C}{C}$ as ordinates, and of w as abscissas, we may find that the value allowable, in order that $\frac{\delta C}{C}$, shall not exceed the negligible amount 0.0001 is about $w = 0°.5$, when the values of φ are between 30° and 60°. This closeness cannot be attained without careful adjustment of the plane of the coils by some such method as that to be described. For a limit $\frac{\delta C}{C}$, $= 0.001$ the value of $w = 2°.5$, about, is sufficiently close,—a closeness easily reached without special attention in a well-made instrument.

Method of adjusting tangent galvanometer to meridian.—Set the graduated circle with line of zero points as nearly as practicable in plane of coils. See that index is very nearly parallel to axis of needle. Turn plane of coil until index is parallel to line of zeros. Then coil is approximately in meridian. Pass constant current to produce about 45° $= \varphi_1$ (defl. of N. end to E), read both ends and take mean $= \varphi_1$. Reverse current and find φ_2. Then $w = \varphi_2 - \varphi_1$. If w is +, the plane of coils is to W. of N.; w is always toward largest deflection. Turn plane in proper direction by w. This will be nearly right, but should be repeated, correcting now for initial position of needle, which is, of course, no longer zero. The proof is as follows:

From page 315, $\tan\varphi_1 - \tan\varphi_2 = \tan\varphi.\ \cos w \left(\frac{1}{1 + \tan\varphi\sin w} - \frac{1}{1 - \tan\varphi\sin w}\right)$; and as $\sin w$ is quite small, $\tan\varphi\sin w$ is negligible in denominators, and $\tan\varphi_1 - \tan\varphi_2 = \tan\varphi.\ \cos w\ (-2\tan\varphi.\ \sin w)$ approx. $= -2\tan^2\varphi.\ \sin w\cos w = -\tan^2\varphi.\ \sin 2w\ \therefore \sin 2w = \frac{\tan\varphi_2 - \tan\varphi_1}{\tan^2\varphi}$. Write $\varphi_2 - \varphi_1 = \Delta$, a *small* angle, and substitute $\varphi_1 = 45° = \varphi$ approx. Then $\sin 2w = \frac{\tan(\varphi_1 + \Delta) - 1}{1}$. Now $\tan(\varphi_1 + \Delta) = \frac{\tan\varphi_1 + \tan\Delta}{1 - \tan\varphi_1\tan\Delta} = \frac{1 + \tan\Delta}{1 - \tan\Delta} = 1 + 2\tan\Delta$ approx. $\therefore \sin 2w - 1 + 2\tan\Delta - 1 = 2\tan\Delta$, and as w and Δ are both small,

$w = \Delta = \varphi_2 - \varphi_1$. For angles other than 45° the general expression for $\sin 2\, w = \frac{\tan \varphi_2 - \tan \varphi}{\tan^2 \varphi}$ must be employed.

RESULTS.

Tangent galvanometer used between 30° and 60°.

	Factor.	Val. of δ for $\frac{\delta C}{C} = \frac{\delta m}{m} =$ 0.001	Values attainable by correction and adjustment. δ	$\frac{\delta C}{C}$
m_1	$\frac{10}{2\pi}$	0.00 16	[$\pi = 3.1416$]	negligible.
m_2	H	0.00 017	0.00 030	0.0018
m_3	r	0.02 cm.	0.02 cm.	0.001
m_4	n	. . . .	0	0
m_5	$\tan \Phi$	$\delta \Phi = 0°.08$	$\delta \Phi = 0°.03$	0.001
m_6	Dimensions of coil sec.	. . . .	$\delta 2b = \delta\, 2d = 0.06$ cm.	0.0001 negl.
m_7	Length of needle.	$2l = 0.9$ cm.	$\delta l = 0.04$ cm.	0.0001 negl.
m_8	Torsion	$\theta = 0.00\,001\,4$	$\delta\theta = 0.00\,000\,14$	0.0001 negl.
m_9	Needle out of centre	$a = 0.7$ .cm	$a = 0.22$ cm.	0.0001 negl.
m_{10}	Incl. of circle from hori.	$h = 2°.6$	$h = 0.8$	0.0001 negl.
m_{11}	Ellipticity of coil.	. . . .	. . . . .	—— negl.
m_{12}	Coils out of vertical	$v = 2°.6$	$v = 0°.8$	0.0001 negl.
m_{13}	Coils out of meridian	$w = 2°.5$	$w = 0°.5$	0.0001 negl.

Inspection shows that the chief source of error is in H. If each m be allowed to affect C by $\frac{\delta C}{C} = 0.001$, the resulting effect will be $\frac{\Delta C}{C} = 0.001 \sqrt{13} = 0.0036$, or about 0.4 per cent. If the corrections and adjustments be made as indicated in columns 4 and 5, we shall have $\left(\frac{\Delta C}{C}\right)^2 = 0.0018^2 + 0.001^2 + 0.001^2 + 7 \times 0.0001^2$ (negl.) $= 0.0023^2$, or $\frac{\Delta C}{C} =$ about 0.25 per cent. Relative current measurements do not involve H, and $\therefore$ for them $\Delta = 0.0014$, or about 0.15 per cent.

Tangent galvanometer. Best range of deflections.—To determine what this range is, we have to consider the effect on $\frac{\Delta C}{C}$ of 1°, a change $\delta \varphi$ in the reading; 2°, the length of the needle; 3°, the torsion of the suspension; 4°, deviation of plane of coils from the magnetic meridian in the original adjustment. It will be shown that if 2° and 3° be corrected, the best working deflection, *i. e.*, the value of φ, which will make $\frac{\Delta C}{C}$ a minimum, is $\varphi = 45°$, but that any deflection from 30 to 60° is not sensibly worse than 45°, and that the range of 20° to 70° is almost as good; giving a range of currents of 3 : 1 in the first case, and 7.5 : 1 in the second. The kind of tangent galvanometer referred to is, of course, the same as elsewhere considered in these notes.

1°. *Change of $\delta \varphi$ in the deflection reading.*—$C = R \tan \varphi \therefore \frac{\delta C}{C} = \frac{2\, \delta \varphi}{\sin 2\, \varphi}$, as before. On any given instrument where φ is read by a circle, an average value of $\delta \varphi$ will be found, which is independent of φ; $\therefore \delta \varphi =$ constant. Hence $\frac{\delta C}{C}$ will be a minimum when $\sin 2\, \varphi$ is a maximum, *i. e.*, when $\varphi = 45°$. Moreover the value of $\frac{\delta C}{C}$ will be symmetrical about the point $\varphi = 45°$, because the value of $\sin 2\, \varphi$ will be so.

$\varphi =$	$\frac{\delta C}{C} = \frac{2\delta\varphi}{\sin 2\varphi} =$
0° or 90°	$\pm\ \infty$
5 or 85	± 0.00589
10 or 80	.00292
15 or 75	.00200
20 or 70	.00156
25 or 65	.00131
30 or 60	.00116
35 or 55	.00107
40 or 50	.00102
45 or 45	.00100

The preceding table gives values of $\frac{\delta C}{C} = \frac{2\, \delta \varphi}{\sin 2\, \varphi}$ for $\delta \varphi = \pm 0°.03$, which would give $\frac{\delta C}{C} = 0.001$ at $\varphi = 45°$ The table might equally well be computed from a table of tangents, since $\frac{\delta C}{C} = \frac{\delta \tan \varphi}{\tan \varphi}$, $\delta \tan \varphi$ being the change for $\delta \varphi = \pm 0°.03$. A curve plotted with values of φ as abscissas and of $\frac{\delta C}{C}$ as ordinates, or inspection of the table, will show that up to $\varphi = 30°$ or 60° the value of $\frac{\delta C}{C}$ changes by but ⅙th its value at 45°, and is therefore sensibly uniform, and even up to $\varphi = 20°$ or 70° it increases by but ½ its value at 45°. Hence as far as $\delta \varphi$ in reading is concerned, the tangent galvanometer of this form is equally precise from 30° to 60°, and almost as much so from 20° to 70°.

2°. *Length of needle.*—The correction for this has been already shown to be zero at $\varphi = 26°.6$. If the correction is made properly or is small enough to be negligible, the resident error will be a minimum at 26°.6, so that as far as this affects the result (*i. e.*, very slightly), the *best* working angle would be slightly under 45°.

3°. *The torsion correction* increases with φ, and hence whether it is corrected or not this would indicate an advantage in small rather than large deflections.

4°. *The deviation of the coils* from the meridian has been shown to be of no effect at $\varphi = 45°$; and as it is difficult, mainly on account of initial torsion, to obtain certainty in this adjustment, there appears here a decided reason for considering $\varphi = 45°$ the best working angle.

On the whole, then, 45° seems the best angle; but when torsion and length of needle are corrected, the range of 30° to 60° is about as good, and even 20° to 70° not decidedly worse; but beyond 20° and 70° the galvanometer should not be employed except in coarse work.

Electro-static capacity. Thomson's and Gott's methods.—[Method described in Kempe's H'b'k of El. Test'g, Ed. 1887, pp. 335, 339.] Formula is $F_x = \frac{R}{R_x} . F$. The battery power used is assumed to be sufficient to enable a

change of the smallest coil in the resistance box to be perceived, so that the precision condition is $\delta R = \delta R_x$. The charges in the condensers, and therefore the sensitiveness of the apparatus, is greatest when the total resistance $R + R_x$ is as large as possible, viz., the total in the box. Hence the magnitude condition is $R + R_x = r$, a constant, or $R_x = r - R$.

By formula XVI. for factors

$$\left(\frac{\Delta F_x}{F_x}\right)^2 = \left(\frac{\delta R}{R}\right)^2 + \left(\frac{\delta R_x}{R_x}\right)^2 = \frac{1}{R^2} + \frac{1}{R_x^2}\,\delta^2 R.$$

Now $\frac{\Delta F_x}{F_x}$ must be a minimum, which will occur when

$\frac{1}{R^2} + \frac{1}{R^2_x}$ is so. By XXX.

$$-\frac{2}{R^3} - \frac{2}{R^3_x}\cdot\frac{d}{dR}\,(r - R) = 0 \therefore \frac{2}{R^3} = \frac{2}{R^3_x}$$

and $R : R_x = 1$ will be the best ratio. But this will hold when $F = F_x$. The best magnitude of F is then F_x; *i. e.*, the known condenser should be equal to the unknown, or that condition should be approached as nearly as may be.

This problem is also capable of a simple solution which may serve to indicate methods for other similar ones. Substituting $R_x = r - R$ gives

$$F_x = \frac{R}{R_x}\cdot F = \frac{R}{r - R}\cdot F.$$

By definition $\frac{\delta F_x}{\delta R} = \frac{d F_x}{d R} \therefore \delta F_x = \frac{d F_x}{d R}\cdot \delta R.$

$$\therefore \delta F_x = \frac{r F}{(r - R)^2}\cdot \delta R \therefore \frac{\delta F_x}{F_x} = \frac{r F}{(r - R)^2}\cdot\frac{r - R}{R F}\cdot$$

$$\delta R = \frac{r}{r - R}\cdot\frac{\delta R}{R}.$$

We have now, for a given value of $\frac{\delta R}{R}$, to find the value of R which will render this a minimum, r being a constant.

$$\therefore \frac{d}{dR}\left(\frac{1}{R(r - R)}\right) = 0 = \frac{-r + 2R}{R(r - R)}, \therefore R = \frac{r}{2}, \text{ or}$$

$R_x = R$, and $F = F_x$.

Magnetometer. In measuring $M \div H$ by the magnetometer, the deflecting magnet is placed successively at two distances, r_1 and r_2 from the needle, producing deflections φ_1 and φ_2. And

$$\frac{M}{H} = \tfrac{1}{2}\cdot\frac{r_1^5 \tan\varphi_1 - r_2^5 \tan\varphi_2}{r_1^2 - r_2^2}.$$

Desired, the best ratio of $r_1 : r_2$; *i. e.*, that which will make $\Delta \frac{M}{H}$ a minimum. The measurements are such that δr_1 and δr_2 may be considered negligible, and $\delta \tan \varphi_1 = \delta \tan \varphi_2$; thus these are the precision conditions. There are no magnitude conditions which bear on this problem. Then

$$\frac{d}{d(\tan\varphi_1)}\left(\frac{M}{H}\right) = \frac{r_1^5}{r_1^2 - r_2^2}, \text{ and } \frac{d}{d(\tan\varphi_2)}\left(\frac{M}{H}\right) =$$

$$\frac{-r_2^5}{r_1^2 - r_2^2}\cdot \therefore \Delta^2\frac{M}{H} = \frac{r_1^{10} + r_2^{10}}{(r_1^2 - r_2^2)^2}\cdot\delta^2(\tan\varphi).$$

To make $\Delta\frac{M}{H}$ a minimum, the fraction in the second member must be a minimum; and we wish, therefore, to find the value of $r_1 : r_2$, which will make it so. Writing, then, $r_1 : r_2 = n$, or $r_1 = nr^2$, and substituting gives

$$\frac{r_1^{10} + r_2^{10}}{(r_1^2 - r_2^2)^2} = \frac{nr_2^{10} + r_2^{10}}{(nr_2^2 - r_2^2)^2} = r_2^6\cdot\frac{n^{10} + 1}{(n^2 - 1)^2},$$

in which we have to find the value of n to produce a minimum. Where the two variables are independent, as in this case r_1 and r_2 are independent, the following proposition may be often of service.

Let $u = f(x, y)$ where x and y are independent variables and f is such a function that it may be separated, so that

$$u = \rho(x).\ \sigma\left(\frac{x}{y}\right).$$

Then the value of $x : y$, which makes $\sigma\left(\frac{x}{y}\right)$ a minimum, is the same as will make u a minimum. For x cannot be expressed as a function of $\left(\frac{x}{y}\right)$, and, therefore, $\rho(x)$ does not enter into the determination of $x : y$ for the minimum. The same is, of course, true if the separation be made into

$$u = \rho'(y).\ \sigma'\left(\frac{x}{y}\right)$$

Then in the problem in hand we have to find the value of n, which will make $\frac{n^{10} + 1}{(n^2 - 1)^2}$ a minimum.

$$\frac{d}{dn}\frac{n^{10} + 1}{(n^2 - 1)^2} = 3n^{10} - 5n^8 - 2 = 0. \therefore n = 1.32 \text{ approx.}$$

Electro-static capacity. Divided charge method.—This problem presents an additional point often arising.

F = capacity of known condenser.
F_x = capacity of unknown condenser.
Q = full charge of known condenser.
q = divided charge of known condenser.
q_x = charge put into unknown condenser, but not measured. Then $q_x : q = F_x : F, \therefore q_x + q : q = Q : q = F_x + F : F, \therefore F_x = F\left(\frac{Q}{q} - 1\right)$. Required the ratio $Q : q$ for greatest precision. Since charges are measured by reflecting galvanometer $\delta Q = \delta q$. By nature of the measurement F is a wholly independent quantity, so that Q is independent of F_x, but q is conditioned by F_x and Q. But in the observations, of course, δQ and δq are independent of these conditions. Hence

$$\Delta^2 F_x = \left(\frac{d F_x}{d Q}\cdot\delta Q\right)^2 + \left(\frac{d F_x}{d q}\cdot\delta q\right)^2 = \left[\left(\frac{F}{q}\right)^2 + \left(-\frac{F Q}{q^2}\right)^2\right]\delta^2 q.$$

Substituting value of F_x and transposing gives

$$\left(\frac{\Delta F_x}{F_x}\right)^2 = \left[\left(\frac{Q}{(Q - q)q}\right)^2 + \left(\frac{1}{Q - q}\right)^2\right]\delta^2 q.$$

Before proceeding to find minimum, we must obtain an expression not containing q in the right-hand member, since q is a function of F_x and Q. Write $q = \frac{Q}{n}$ where n is the desired ratio $Q : q$, and substitute. Then

$$\frac{\Delta F_x}{F_x} = \frac{n^4 + n^2}{(n - 1)^2 Q^2}\cdot\delta^2 q.$$

For a minimum the value of n must make the fraction

in the second member a minimum, and, therefore, by the proposition given in the magnetometer problem, as before.

$$\frac{d}{dn}\frac{n^4+n^2}{(n-1)^2}=0.$$

The solution of this gives $n^3-2n^2-1=0$, $n=2.2$ approx.

Battery resistance. In measuring battery resistance B by two deflections, assuming resistance box to be so exact that its errors may be neglected :—

1°. With any galvanometer for which $\delta\ C=$ constant, *e.g.*, a reflecting galvanometer. Call ρ_1 and ρ_2 the total resistances in circuit, inclusive of battery, when C_1 and C_2 are flowing. Then

$$\Delta^2 B=\left[\left(\frac{-\rho_1^2\rho_2}{E(\rho_2-\rho_1)}\right)^2+\left(\frac{\rho_1\rho_2}{E(\rho_2-\rho_1)}\right)^2\right]\delta^2\ C.$$

For best results we must make $C_1=2.2\ C_2$, *i. e.*, $\rho_2=2.2\ \rho_1$, and $\frac{\rho_1}{B}$ as small as possible consistently with avoidance of polarization effects. If $C_1=2\ C_2$ about, then $\frac{\Delta B}{B}=\sqrt{20}\ \frac{\rho_1}{B}\cdot\frac{\delta\ C}{C}$. To obtain $\frac{\Delta B}{B}$ with assigned closeness, we must use galvanometer of such sensitiveness that $\frac{\delta\ C}{C}<\frac{1}{\sqrt{20}}\cdot\frac{B}{\rho_1}\cdot\frac{\Delta B}{B}$.

2°. With any galvanometer for which $\frac{\delta\ C}{C}=$ constant, *e. g.*, a tangent galvanometer, $\Delta B=\sqrt{2}\ \frac{\rho_2\rho_1}{\rho_2-\rho_1}\cdot\frac{\delta\ C}{C}$. For best results C_1 should be as large and C_2 as small as is consistent with polarization and requisite sensitiveness. In a tangent galvanometer, using deflections of 60° and 30° for C_1 and C_2, respectively, the ratios will be about $C_1=3\ C_2$, *i. e.*, $\rho_2=3\ \rho_1$. Then $\frac{\Delta B}{B}=\frac{3}{\sqrt{2}}\cdot\frac{\rho 1}{B}\cdot\frac{\delta\ C}{C}=\frac{2\rho_1}{B}\cdot\frac{\delta\ C}{C}$ approx. Hence for best results with assigned value of $\frac{\Delta B}{B}$ we must make $\frac{\rho_1}{B}$ as small as is consistent with polarization and sensitiveness, and must use galvanometer of such sensitiveness that $\frac{\delta\ C}{C}<\frac{B}{2\rho_1}\ \frac{\Delta B}{B}$, and that with this value of $\frac{\rho_1}{B}$ the deflection will be about 60°. We must make ρ_2 such that the second deflection $=$ about 30°. If deflections of 70° and 20° are used with a galvanometer having the same value of $\frac{\delta\ C}{C}$ at these points as the former at 60° and 30°, the value of $\frac{\delta B}{B}$ will be about 0.8 as great. Still better results may be reached by the use of a potential galvanometer, together with a current galvanometer or external circuit of known resistance.

Battery e. m. f. By two deflections.

1°. For galvanometer where $\delta\ C=$ constant. $\Delta^2 E=\frac{\rho_2^4+\rho_1^4}{(\rho_2-\rho_1)^2}\cdot\delta^2\ C$, and inserting $x=\frac{\rho_2}{\rho_1}$ and $E=C_1\ \rho_1$, $\frac{\Delta^2 E}{E^2}=\frac{1+x^4}{(x-1)^2}\cdot\frac{\delta^2\ C}{C^2}$, which will be a minimum when $x=\frac{\rho_2}{\rho_1}=2.$ approx. The best ratio of the currents is, then $C_1=2.1\ C_2$, or sensibly the same as for the measurement of B. The value of $\frac{\Delta E}{E}$ is independent of the actual value of the resistance, as it involves only their ratio $\rho_2:\rho_1$.

2°. For galvanometer where $\frac{\delta C}{C}=$ const. $\frac{\Delta^2 E}{E^2}=\frac{\rho_2^2+\rho_1^2}{(\rho_2-\rho_1)^2}\cdot\frac{\delta^2\ C}{C^2}$ which has no minimum, but which diminishes as ρ_2 increases, or as ρ_1 diminishes, as may be best seen by inspection after writing the fraction in the form $\frac{\rho_2^2+\rho_1^2}{\rho_2^2+\rho_1^2-2\rho_2\rho_1}$. Hence we must make ρ_1 as small and ρ_2 as large as is practicable with due regard to polarization and sensitiveness.

Rogers' Laboratory of Physics, March 1888.

PRACTICAL NOTES CONCERNING THE CONSTRUCTION, USE AND MANAGEMENT OF STORAGE BATTERIES.[1]

BY A. RECKENZAUN.

(Continued from page 390, vol. vi.)

EXPERIMENTS WITH STORAGE BATTERY CARS.

During the month of December, 1887, a series of tests were instituted with electrical tramcars driven by accumulators and electric motors. Some of the tests were made with car No. 3 in the large yard of the Electric Car Company of America, in Philadelphia, and others with a second car sometimes on this experimental line and sometimes in the streets of the city named. These cars varied in dimensions, and they were differently constructed, therefore we attach numbers to each in order to distinguish them hereafter. The yard in which the rails were laid is an irregularly shaped four-sided space, and there are four curves, two of which have a radius of 50 feet, one 33 feet, and one 100 feet, measured to the centre of the track. The rails formed a complete circuit of 1,005 feet in length, and this we call one round trip. The rails tangential to the 33 feet curve were laid upon an ascending incline of 1 in 20, sloping down again beyond the summit of the hill at the rate of 6 feet in 100, and this slope finished with the 100 feet radius curve.

Car No. 3 contained 116 cells, all of which were used during this experiment in supplying current to two of the author's electro motors, which were fixed to a pair of bogies. The entire weight propelled was 7.4 tons; the battery alone weighed 2.14 tons, the rest being made up by the car itself, the motors and gearing, and the passengers on board.

Three men, each well trained for his work, were required for these tests, and their duties were as follows:—One man took charge of the switch in front of the car and the brake; in fact, he did the ordinary duties of a driver, taking care that the car ran at regulation speed on the level, that it did not "race down grades" nor go too slow up the inclines, and that it took the sharpest curves with safety. The second man with a timepiece in his hand counted the number of round trips and recorded it carefully, he also watched the voltmeter periodically. The third attendant had the most difficult task of taking readings on the ammeter and writing them down as fast as his skilled hand and pencil would allow it. It will be noticed that on a line of this description with constantly recurring curves and no straight piece of track of more than 200 feet in length, the energy consumed must vary continually. A sensitive ammeter, as near dead-beat as it can be made, was used, and the attendant could take and write down 41 readings during a round trip lasting on an average 1.45 minutes. This gave one reading to every two seconds about, and in order to do this with approximate accuracy some practice was required. Very few stoppages were made because it was the intention to ascertain the number of miles this car could make with one charge of accumulators on this awkward track, without allowing the

1. From the *Telegraphic Journal and Electrical Review* (London).

E. M. F. to drop below a certain minimum, and this minimum was fixed at 10 per cent. drop. The E. M. F. was taken every half hour; at the commencement the entire battery gave 227.36 volts when the car ran on a comparatively level part of the track, and this corresponds to 1.975 volts per cell. At the end of the experiment, the battery gave 205.42 volts under similar conditions, consequently there was a loss of nearly 22 volts between the first and the last readings. When near the summit of the hill the greatest amount of current, averaging 80 amperes, was used, and at that instant the E. M. F. dropped by about 14 volts below that used on the level, but it recovered immediately when the circuit was entirely broken on the down grade, or when reduced to its normal value on the level road.

The temperature of the air varied between 30° and 36° F., the rails were dry and tolerably clean, and we made 331 round trips, each of 1,005 feet, in exactly eight hours. This represented a total distance of 63 miles, or an average of nearly eight miles an hour. From the plan of the line we computed that the car had to traverse 5.438 miles of curved track of 33 feet radius; 10.4 miles of 50 feet radius, and 4.918 miles of 100 feet radius. The aggregate of ascending grades came to 5.656 miles, and the down grades to 5.128 miles, whilst the entire distance of straight and level track gave 22.46 miles.

About 13,000 observations were recorded on paper, these were averaged and gave a mean current rate of 18.5 amperes; down the grade and for a good distance beyond, the car was run by gravity; on leaving the 33 foot curve and entering the up grade the current gradually rose from 40 to 80 amperes, and on the level it varied between 10 and 15 amperes. By "level," we mean *comparatively* level, because the ground had undulations which represented slight gradients, but these were averaged up so as to give the value of a straight track.

The energy was thus consumed at an average rate of $216 \times 18.5 = 3{,}996$ watts; this gives 5.35 h. p., and for the entire 63 miles, 42.8 h. p. hours.

The maximum energy supplied at any moment by the battery was $213 \times 80 = 17{,}040$ watts $= 22.84$ h. p. Each car mile costs in this case .663 of a horse-power hour, which can easily be expressed in money value when we know the price of a horse-power hour in the prime mover. From the above it will be seen that the useful storage capacity of the accumulators was 148 ampere hours. Before the experiment commenced, the specific gravity of the acid in each cell was ascertained, and the average calculated, this gave 1,186 degrees. Immediately after the 63 miles, or 8 hours' run, the acid was again tested and gave an average of 1,130 degrees for the whole set; consequently, there was a fall of 56 degrees, which would give 1.3 degrees per horse-power hour, or nearly .89 degrees per car mile run.

The work done may also be expressed in ton miles, $7.4 \times 63 = 466.2$ ton miles, which caused an expenditure of 42.8 h. p. hours, or 10.88 ton miles per horse-power hour.

After the above experiment the accumulators were recharged until the acid density rose to 1,190 and gas bubbles came off freely. The average energy consumed during the charge was 6,181 watts for 7.5 consecutive hours, giving a total of 62.14 electrical horse-power hours. The cells were not new, but they have served the purposes of electric traction for six months preceding the present record.

As we are treating of the properties and uses of accumulators in particular, there is no need to give detailed descriptions of the construction of the motors, gearing, and other mechanical parts of cars, The efficiency and durability of the battery, however, is materially influenced by the efficiency of the devices used for propelling the vehicle, consequently a few remarks on constructive details will prove of service hereafter. Car No. 3, mentioned in the preceding article, was mounted on two bogies whose wheel-bases were comparatively short, 3 feet 8 inches; this gave great freedom of motion round the curves. The gauge of the track in Philadelphia is 5 feet 2¼ inches. and the rails are of the usual type used in that city, called the "flat rail." The power was transmitted between the motors and axles by means of worm gearing attached to one axle of each bogie. Variations of current to suit the requirements of tractive resistance were effected by varying the resistances in the motors. Each field magnet core was wound with two distinct coils, which by means of a suitable switch could be thrown in parallel or in series, and the motors, as a whole, could be worked in parallel, in series or singly. Thus a number of changes could be made without resorting to artificial resistances, and without excessive currents flowing at the start. Car No. 3 was specially built for electric traction; its length is 22 feet inside, 28 feet 2 inches over platforms, and 7 feet 6 inches wide over all. Car No. 1 is different in many respects. One motor only is used (Sprague type), which is geared to the aft axle by means of a pinion and spur wheel. The wheel base is 6 feet, there are only two axles, one of which is driven, and the car is of the ordinary two-horse type, 16 feet long in the body and 21 feet over the platforms. The accumulators were of the same type as those in car No. 3, but only 84 in number, arranged under the seats. The weight of this vehicle during the tests, with several men on board, was 5.3 tons. The conditions of the line and the atmosphere were similar to those in the former experiments. With this set of fully charged accumulators we made 231 round trips in 6½ hours, representing a distance of 43 8 miles. On an average, 22.6 amperes of current were used; the maximum on the grade of 5 per cent. rise was 70 amperes, on the level 20 to 25 amperes. Round the curves, owing to the greater wheel-base, this car ran slower than car No. 3 with the same amount of current, and the mean speed was just 7 miles per hour. The specific gravity of the cells averaged 1.184 degrees before the car started on its journey, and it dropped to 1.123 at the end, giving a difference of 61 degrees for 43.8 miles, or 1.415 degrees per car mile. Calculating the mean E. M. F. at 157 volts from actual measurements, we get an average of 4.75 h. p., giving a consumption of 29.69 h. p. hours supplied by the battery, whilst the maximum energy given off at any moment was $70 \times 150 = 10{,}500$ watts $= 14$ electrical horse-power.

Converting the work into ton miles, which is no doubt the most rational mode of comparing figures, we get $5.3 \times 43.8 = 232.14$ ton miles at an expenditure of 29.69 h. p. hours, and this gives nearly 7.78 ton miles per horse-power hour.

The energy expended per car mile was .678 h. p. hours; it will be seen that this was very little less in the case of car No. 3, yet there is a difference of 28 per cent. in favor of this car when we compare the relative consumption per ton mile. The re-charging of car No. 1 took 6 hours, at an average rate of 5,410 watts, and this amounted to 43.5 h. p. hours, with a fair overcharge. We find that in the case of tramcar propulsion, where the batteries are worked at a comparatively high rate, the efficiency of the accumulator never reaches above 70 per cent., measuring the energy at the terminals of the battery, both when charging and discharging, although the efficiency in ampere hours often exceeds 80 per cent; but this latter mode of expressing efficiencies is of little practical value.

EFFECT OF CONDITION OF ROAD UPON STORAGE BATTERY.

It will be seen that there is a great difference in the rate of current consumed according to the state the rails are in at different times. As a matter of fact the streets of Philadelphia are about the dirtiest of any city in the States, and there is sometimes so much dust that one can hardly see the top of the rails in places where much cross traffic occurs, through market carts and all sorts of wagons. After a good shower of rain the tram rails assume a tolerable clean appearance; there being no grooves except at curves, the mud is easily squeezed out by the flanges of the

car wheels; thus it happens that during or after a rainfall the energy necessary for propelling the vehicle is very much smaller than in dry weather. Although car No. 1 has made hundreds of trips through the city, *via* Spruce and Pine streets and Walnut and Chestnut streets, prior to the time when this record was made, we have only on very few occasions taken readings systematically. On one of these occasions we carried only about a dozen passengers; the weather was damp and therefore favorable. Readings were taken on the ammeter only, at the same rapid rate as formerly on the experimental track, and we worked out the averages between each "square," the streets of that city, as is well known, being divided into squares; at each square is a cross street, so that the rails of all the lines running at right angles to a certain route intersect, on an average, every 200 yards.

As our car ran faster than the horse car in front of us, we had to stop as often as they did when taking up and putting down passengers, or letting other traffic pass at the numerous crossings. Thus, on one round trip between Graysferry and the Exchange and back again, we used only 21 amperes of current on an average, each single trip taking about 40 minutes, the distance being 3½ miles. The maximum current at the grades and curves or both combined, amounted to 64.3 amperes. In order to show how irregularly the energy is consumed even on lines with moderate grades, we give here a few figures as examples. Taking the 10 squares in Pine street, going "up-town," the average currents for each square were 45.31 amperes between Fourth street and Fifth street, 40.31 between Fifth and Sixth, 16.05 between Sixth and Seventh, then 43.5, 21.05, 14.04, 30.58, 0, 16.53, and 27.7 between Thirteenth and Broad streets. On the return journey "downtown" through Spruce street, which is parallel to and next to Pine street, the currents were 9.16 amperes between Broad and Thirteenth streets, 0 between Thirteenth and Twelfth, then 13.84, 24.28, 28.0, 18, 9.4, 24.04, 20, and 17.15 between Fifth and Fourth streets respectively.

On another occasion, with the rails clogged with dry dirt, and 23 passengers on the car when going "downtown" and 40 passengers when returning, the currents between the same streets were as follows, viz.:—going from the Fourth street towards Broad street 48.66, 41.76, 20.55, 67.69, 43.43, 10, 36.25, 20.27, 22.85 and 33.33 amperes respectively. Returning again from Broad street to Fourth street, we had 31.25, 21.05, 42.64, 8.26, 26.59, 0, 16.53, 41.66, 0, and 20.62 amperes respectively. During the entire trip the average current rate was 36 amperes.

No. 3 car hauling No 1.—Tests were made to ascertain the current consumed by car No. 3 when propelling itself as well as car No. 1 attached to it, the apparatus of the latter being kept inactive during the experiment. Instead of running the vehicles round continuously, a start was made for each trip of 1,005 feet on our experimental line. Thus the current used on one trip of 1.5 minutes' duration was 41.1 amperes. The total weight propelled was 12.3 tons; the currents on the 5 per cent grade and on the 33 feet curve were necessarily very high, and the E. M. F. varied considerably owing to the great strain put upon the accumulator of the locomotive car; thus the E. M. F. on open circuit before starting gave 234 volts, at the instant of starting 220.5 volts, when going round the 33 feet curve 216 volts, and on the level 225 volts, and immediately after the car stopped it rose again to 230 on open circuit.

EXPERIMENTS WITH STORAGE BATTERY CARS.

Car No. 3, with a constant load of 7.4 tons, was next subjected to different tests by varying the number of cells actually in use; the cells were simply cut out of circuit, but they were kept on board so as not to diminish the weight carried. The track in the yard was in good condition, and the car was stopped and started at the end of each round trip of 1,005 feet. Four points of the switch were used, and for each point or position, which represented a distinct combination in the motor circuits, the speed of the car was ascertained. Thus, with 100 cells in use, and with the switch handle at the first notch when the motor circuit gave the highest resistance, since all the coils were placed in series, it took 2 minutes and 30 seconds to go once round from the instant of starting to a dead stop with the brake on; this gave an average speed at the rate of 4.56 miles an hour. With the switch handle at the second point the trip was made in 1 minute 50 seconds, equal to a rate of 6.218 miles an hour. At the third combination 1 minute 15 seconds, giving 9.12 miles; and with the fourth combination 1 minute and 5 seconds, showing a rate of 10.52 miles per hour, including time taken in starting and stopping.

With 90 cells in use the time taken on each round trip was as follows: first point on switch 2 minutes 53 seconds; second point, 1 minute 53 seconds; third point, 1 minute 20 seconds, and with the fourth combination 1 minute 10 seconds.

Then 80 cells were coupled up in series; with the switch handle at the first notch the car went all right until it nearly reached the summit of the hill where the grade is 5.5 per cent. for a short distance, and then it came to a standstill; the power with all the motor coils in series and the reduced E. M. F. was not sufficient to bring the load over this grade. The second combination gave ample power and the trip was made in 2 minutes 4 seconds; the third point 1 minute 35 seconds, and the fourth 1 minute 20 seconds.

With only 60 cells in use, and the load of 7.4 tons, we started on the third notch, which carried the car over the track easily in 1 minute 57 seconds; and the fourth notch, representing a powerful combination, completed the journey in 1 minute 20 seconds.

These tests were valuable in so far as they gave the exact speed for each position of the switch handle, and especially the results with different numbers of storage batteries. For ordinary speeds, and grades of the description given on page 7, we found that 100 cells showed the most economical results with all the variations of speed and power.

EFFECT OF SNOW ON THE TRACK.

In anticipation of severe snow storms, which occur so frequently in many parts of the United States, car No. 1 was fitted with a snow plow and wire brushes. This plow was ingeniously constructed; the shears were fixed to a balanced frame underneath the front platform of the car. Very little pressure on a stud, which could be moved up and down by the foot of the driver, brought the shears into contact with the rails. Immediately behind the plow-shears, and just ahead of the front wheels of the car, were brushes (made of stiff steel wires), and these were kept scraping on the rails by means of weights. The plow served the purpose of removing the bulk of the snow, and the brushes swept the rails and grooves clean in front of the wheel flanges. One day it snowed very hard, and when the rails were covered to about one-quarter of an inch we took this car out, using merely the wire brushes and a little sand on the steepest grade. The first round trip over this snowed up ground took 2 minutes and 8 seconds, but it cleared the track completely; the average current used was 50 amperes. Twenty trips were then made in succession, taking on an average 1 minute and 45 seconds, with a mean current of 30 amperes, snow falling hard all the time.

Then we allowed the snow to accumulate for four hours until it was about 2 inches deep; on starting the car, and during the first journey, the plow, the brushes, and sand had to be called into requisition. The current used averaged 80 amperes, and the time 2 minutes and 20 seconds; but each succeeding trip took less time and less current,

until it reached its normal value. This shows that with proper appliances, and with cars rapidly succeeding each other, the track can be kept clear; but the accumulation of much snow in the first instance occasions a fearful demand of energy, and without plow and brushes the snow is compressed by the wheels, and renders locomotion almost impossible.

On one occasion snow was shoveled upon the track 4 inches deep and beaten down; the car started with great difficulty, because the shears and brushes were practically buried; but with a skillful manipulation on the part of the driver, by going forwards and backwards a few inches at the start, and using sand from the automatic sand-box, provided for the purpose, the vehicle cleared itself and made its journey, slowly at first, gradually a little faster, until at last a tolerably clean rail was obtained by the traffic over it.

Without plow and brushes it is not only very difficult to make any progress through snow, no matter what power there be at disposal, but the car wheels are very apt to leave the track and ride over the compressed snow, which gets as hard as ice, when it can only be removed by the application of crowbars and scrapers, or a free use of salt.

A properly constructed ammeter will give more faithful indications than a dynamometer, and the minutest variations in tractive force can thereby be ascertained in an instant, since there is neither momentum nor friction of measuring instruments to be accounted for. By careful observations we were enabled to record the effect of various comparatively small obstacles upon the rails, and we have found that dry dust and snow virtually doubled and trebled the energy which was found necessary on clean or moist rails.

A simple calculation will show that there is no worse policy than economy in looking after the condition of tracks. The slightest attention to this requirement will show a very material saving of power. Tramway engineers know this to some extent, but they have evidently not found out the exact numerical value of cleanliness, otherwise they would be more particular. An electric car will run twice the distance with the same amount of energy on a clean wet rail that it will on a dry one with grooves full of dust. With storage battery cars, careful attention to the road will especially count, since the life of the cells can be more than doubled with half the rate of discharge. Considering the vital importance of these facts, we need not apologize for the rather lengthy treatment of this branch of our subject. By reducing the tractive resistance we can diminish the weight of the battery, or increase its durability, the cost of cleaning the rails will be more than recouped by the smaller depreciation of the plates, and the saving of propelling power may be taken as a clear gain.

(To be continued.)

ABSTRACTS AND EXTRACTS.

SCIENTIFIC RESEARCH.[1]

"In the early years after the foundation of the government a few great men were interested in the philosophy of science, in its facts, and in research. Franklin was a physicist, Jefferson a naturalist, and Gallatin an anthropologist. These and other great men of the time drank deeply at the fountain of science; but they were statesmen, or they had other callings and made the advancement of science a secondary purpose. But slowly scientific men rose, one after another, who devoted their entire energies to research. In the last generation a galaxy of great scientific men appeared in the American firmament; Henry, Bache, Pierce, the Rogers brothers, Gray, Baird, and many others. These men devoted their lives to research and instruction in science. In 1840 they organized the Association of Geologists and Naturalists, and in 1848 they transformed that society into the American Association for the Advancement of Science. Since that time the society has embraced in its membership all or nearly all of the scientific men of America, and in the list of its officers—presidents, vice-presidents, and secretaries—the names of many of the illustrious scientific men of the country are enrolled.

"Most of the great men of that generation have sailed away on the unknown sea. A few only, like Dana, Hall, Newberry, and Lesley, remain to guide in our councils and to cheer on the labors of the present generation of investigators. The society which they organized has grown with the growth of the country and the far more rapid growth of science, until it embraces a membership that constitutes a vast corps of laborers who occupy the border land of knowledge, which is the field of research. To enumerate in systematic order the fields of research occupied by the various members of this association would be to formulate a classification of the sciences.

"Atoms, mountains, and worlds, with all inorganic bodies and all inorganic motions, are to be examined in the study of the inorganic realm. The phenomena of nature are qualitative and quantitative, and out of quantitative relation the abstract science of mathematics has been developed, and this science of measurement is rapidly being applied to the qualitative sciences. There are many men engaged in mathematical researches. There are members who study the stars, compute their distances, and determine their courses, and who are seeking to solve the mysteries of the constitution of the bright sun and the pale moon: for on the chariot of light they drive through the storms of the greater orb and explore the dim fields of the lesser. Others with patient labor seek to discover the nature of light, of electricity, and of gravity—the mysterious force that impels the universe. There are others, many others, who are investigating the minute constitution of matter and determining its many forms. These forms are for ever changing. The crystals of the rocks that make up the mountain mass are dissolved and their atoms redistributed in new forms, and chemical changes are in progress wherever human investigation can penetrate. The tree grows and decays, and man is but a form—a mould, through which streams of atoms pour in waves of chemic change. So the chemist studies the laws which govern the constitution of bodies and under which they are for ever in flux. There are others who are studying the molar motions and mechanical powers by which waters are made to turn mills, winds to waft vessels, and steam to drag cars. There are others who study the atmosphere which bathes the earth. They study the coming and going of storms, where fierce cyclones are born, how the cold wave creeps from polar regions, and the hot wave from the tropics. There are others who are studying the surface of the earth—the lands and seas in all their places and forms. At the far North there is a region walled by ice, a million and a half square miles in extent; but even into this land of ice they penetrate. About the South Pole there is an area of seven million square miles enclosed by a barrier of ice—an unknown region into which the modern scholar is bound to enter. Between these walls the whole habitable earth is spread, and they are exploring all its seas, navigating all its rivers, climbing all its mountains, and threading all its cañons.

"A great army of men is engaged in the study of the constitution of the earth—the origin of mountains and valleys, of hills and prairies, of volcanoes and geysers, of cataracts and caves, and of rivers and lakes and seas. They examine the great coral reefs and islands of the sea, and they study the great coral rocks of the land—the fossil reefs and islands of ages gone by. Climbing among cliffs, they study the anatomy of dead volcanoes, and climbing to the brink of craters, they study the physiology of living volcanoes. If an earthquake rends the rocks, they measure the vibrations of its waves, and with the eye of science penetrate to the centre of the disturbance, and draw upon their maps the lines of weakness in the crust of the earth. They follow the sands that are washed by storms from the mountain sides until they find them built by the sea into islands and coasts. With microscope and crucible they study the constitution of granite, basalt, trachyte, and other rocks, wherein appear the crystal forms of many minerals. They show that the grand mountain form, with its crags, and peaks, and grottoes, where forests stand, where lakes are embosomed, and where cataracts flash in the sunshine, is indeed an aggregation of many gems beautiful in form and brilliant in color.

"But man is not satisfied with the knowledge which comes with the study of the inorganic realm; he essays to solve the mysteries of life. An army of men is engaged in the investigation of vegetable life. They find minute but beautiful plants that grow as dust on polar ice; in dank fields they find fungi, on rocks they find mosses, on the waves they find sea-weeds, on tropical trees they find orchids, on the prairies they find asters, in the savannas they find lilies, in the jungle they find palms, in the forests they find oaks, on the mountain flanks they find sequoias; and they study all these forms and a thousand more, and out of their study grows the science of botany. Then they must know how these forms became, and they trace their origin in the dim past, and they exhume the forms of plant life from the tombs of ancient meadows and groves.

"Then another army of men is engaged in the investigation of

1. From the address of Major J. W. Powell, Director of the United States Geological Survey, delivered as President of the American Association for the Advancement of Science at the Cleveland meeting, August 15.

animal life, and they find the land and sea teeming with varied forms. In the sea the coral animals grow and build their weird structures. On the bottom and shores of the sea mollusks crawl, carrying with them their pearl-lined homes. There are mollusks in all the lakes, in all the rivers, in all the brooks, and in all the ponds, and they wander over the lands and climb the trees. On the lands there are crawling worms, and in the seas crawling articulates, and the world is covered with crawling insects. The ants live in cities of their own building, the bees live on the clover blossoms, and the butterflies play among the roses. The fishes swim in the waters, the reptiles crawl in the marshes, the birds fly in the air, and the beasts roam over the land. These animal forms are studied and classified, and we have systematic zoölogy. But this is not all of zoölogy. In the life of every living thing there is a wonderful history of transformation; so zoölogists study the birth, growth, and death of animals. Then they discover the origin of present tribes, by investigating the forms of life that have existed in the past, and they call upon the rocks to reveal their evolution.

"Man essays to learn the marvelous structure of the human form, and the working of this complicated organism, and the processes by which the materials of the world are transformed into brawn and brain, and by which the powers of the dead universe are transformed into life. This study gives us the science of human biology. Having learned how men live, scholars seek to learn how men may live longer. In his quest to know, man has transformed plains into fields, prairies into gardens, forests into orchards, tribes of wild beasts into herds and flocks; he makes the cataract his slave, and laughs at the lightning; the multitude of enemies by which he was once surrounded have now become his friends; in his puissance he seems to have conquered all; but while he has subdued many of his great enemies, he is surrounded by hosts of infinitesimal foes. He fears no attack of the lion, but he surrenders in death at the attack of the microbe, yet by light of science he seeks to disarm and destroy these infinitesimal foes.

"Man is an animal in body, stomach, and legs; but then he is an animal with opinions, and forever he has been systematizing these opinions into philosophies. In the earliest philosophy everything was endowed with life and deified—stones, trees, fountains, forests, beasts, winds, waves, and stars; and the mysteries of the universe were explained by making all these things intelligent actors. From this, the earliest philosophy of the lowest savage, it is a long way to the philosophy of science, and there have been many stages. That hollow dome, the firmament, has become infinite space; the wind, that was at first believed to be the breath of beasts stationed at the four corners of the earth, has at last become the circumambient air in motion under physical laws; the flat space of earth has become a globe; astrology has become astronomy; alchemy has become chemistry; witchcraft has become medicine; beast gods have become domestic animals; and nature gods have become energies that can be used as the servants of man. The history of these opinions and of the philosophies into which they are woven is now a theme for the investigation of many men.

"So the members of this society are prosecuting investigations in the realms of motion, life, and mind; and there is such a division of labor that every great science included in these realms has its devotees. It is a goodly work, it is a grand work."

ELECTROLYSIS OF IRON SALTS.[1]

BY ALEXANDER WATT.

(Concluded from page 302.)

Persulphate of Iron and Sulphate of Potassa.—A weak solution of the persulphate was first obtained, to which was added a solution of sulphate of potash. With the current from four Daniell cells and large anode surface, a bright deposit of iron of a steel grey color was obtained upon a brass plate soon after immersion. The deposition was rather slow at first, until the anode surface was increased, and there was a good deal of hydrogen given off. After the plate had been in the bath about half an hour, a good coating of iron was obtained on both sides of the plate, and small crystals of metallic iron were found attached to one corner of the plate, showing that the deposition had really proceeded with some rapidity during the time.

Persulphate of Iron and Sulphate of Ammonium.—It was next determined to ascertain if the addition of sulphate of ammonia to a solution of the persulphate of iron would favor the deposition of the metal. For this purpose a dilute solution of the persalt was taken, and to this was added a small quantity of sulphate of ammonia, which was dissolved, with stirring, in the liquid. On immersing a brass plate in this bath—the current from three Daniells being used—it at once became coated with a film of iron of a darkish color, the upper portion of which was of a blue tint. The current being evidently too strong, a single cell was next tried, when a prompt deposit of iron of a dark grey was received upon a fresh plate. The solution was now diluted with water, and a new plate immersed, when the deposition took place more gradually, and indeed too slowly. Two more cells were now added, when the film upon a fresh plate was at first of a blue color, but after a few moments it became tolerably white, and was perfectly reguline and adherent, the deposit having taken place on both sides of the plate, proving that the solution was a fairly good conductor. I may say that this result somewhat surprised me, for although I had succeeded in obtaining metallic deposits from iron persalts from various solutions, *as a matter of fact*, I never expected that a tolerably good depositing solution could be formed from such salts; but this, so far as I have gone with this latter experiment, really appears to be the case.

Persulphate of Iron and Sulphate of Soda.—A solution was formed by adding to a rather weak neutral solution of persulphate of iron, powdered sulphate of soda crystals, a little at a time, and stirring the liquid until this salt was dissolved. With the current from three Daniells, a deposit of iron at once commenced to form on the corners of a brass cathode, the film gradually increasing until the whole of the immersed surface—about two square inches—was covered. The deposit, which was of a blue-grey color was very streaky and irregular; to remedy this, if possible, the bath was further weakened by addition of water, which somewhat improved the character of the film; but this, however, still remained patchy or mottled. The bath was again diluted, at which point it was exceedingly weak, but still yielded a prompt coating of iron upon a clean brass plate. To obtain a uniform coating, and to improve the color of the film if possible, the plate was now gently moved about in the bath—a large anode surface being exposed—when the metal deposited in a more uniform condition and of a good white color. The results thus obtained further indicate the direction in which we must steer if we wish to obtain metallic deposits of iron from solutions of its persalts, with or without the admixture of other substances, namely, in the direction of the pump. Extreme dilution of the electrolyte appears to be an absolutely necessary condition. Although solutions of the persalts of iron have no practical significance so far as relates to the deposition of the metal upon other metallic surfaces for the purposes of art, I was desirous, in these latter experiments, to ascertain, *first*, if iron could be deposited at all from any or all of these solutions; and *second*, under what conditions. In my first experiments with the persalts I was, in common with others, unsuccessful, and it was not until I had obtained an actual film of reguline metal from a pernitrate solution, that I became convinced of the possibility of reducing the metal from persalts provided the proper conditions could be arrived at. Those conditions I discovered after a very extensive and tedious course of experiments, and if I were to go over the same ground again I should exactly reverse the basis on which they were conducted; for, instead of commencing with a moderately strong solution of any given persalt, and gradually reducing its strength, as occasion required, by additions of water, I should start with a measured quantity of water, and to this would add, by small quantities at a time, a concentrated solution of the salt under trial, these additions being made until a film of iron appeared upon a clean brass or copper cathode.

Perphosphate of Iron.—Hydrated peroxide of iron was digested in a boiling solution of phosphoric acid, and the solution afterwards filtered and diluted with water. With a current from three Daniells a blue film of iron was first obtained upon a brass plate, but after a few minutes immersion the deposited metal acquired the characteristic color of iron, though not so white as that obtained from a solution of the protosalt.

Lactate of Iron.—A solution of this salt was first prepared by digesting a quantity of fine iron wire in a strong solution of lactic acid for many hours, when a pale green solution resulted, which, after moderate dilution, was electrolyzed with the current from three Daniells in series. There was a brisk liberation of hydrogen, and after a few minutes immersion of a brass cathode a film of iron of a somewhat dark color appeared upon its surface. No deposit could be obtained with a smaller number of cells than those mentioned. A solution of lactate of iron was also prepared by dissolving carbonate of iron in a strong and warm solution of lactic acid, and the liquid was used in its warm condition with the same number of cells, when a prompt film of iron was obtained upon a brass plate, but the color, as before, was of a dark color.

Perlactate of Iron.—A strong solution of lactic acid was first heated, and moist hydrated peroxide of iron then introduced in small quantities at a time, and the heat kept up until the acid was neutralized. The vessel was then set aside until cool, and the clear liquor, which was of a deep orange color, was afterwards decanted for use. With the current from three Daniells in series, a dark colored and somewhat iridescent film of iron slowly formed upon a brass cathode, and this was found to be firmly adherent. The solution was then gently heated, and tried with the same current, when the deposit was somewhat more prompt, and the color of the film improved, especially when the plate was slowly moved about in the bath.

In pursuing the experiments described in this and the preceding papers, my aim was to obtain deposits of metallic iron, if possible, from even the most refractory iron salts, and in this, I am pleased to say, I generally succeeded, by making such modifica-

1. From the *Electrician* (London).

tions of current strength and density of the electrolytes operated upon, as from time to time occurred to me. In arriving at more or less satisfactory results with solutions that presented much difficulty, I frequently had to make a very considerable number of trials before I succeeded in finding out the conditions necessary to obtain the desired film of iron of a proper reguline character. When these conditions were approached, further investigation was often necessary to ascertain whether further modifications would give still better results; and it was not until such additional trials had been made that I felt satisfied with the final result of my labor. From a practical point of view, I am fully aware that many of the experiments I have recorded will have but little interest. To the student of electro-metallurgy, however, the behavior of various solutions of metallic salts under electrolysis cannot fail to possess at least the interest which always attaches to fact. Indeed, when we consider the comparatively meagre information which has been furnished us by the various investigators of electro-chemical phenomena, concerning the electrolysis of metallic solutions other than those which have a more or less practical application in the arts, it would appear that further investigation should be made in this direction, and to this agreeable task I have for some time past—and purpose continuing to do so—devoted myself, believing that not only the student, but the practical electro-metallurgist, may derive some beneficial knowledge from the records of electrolytic experiments with a considerable number of metallic solutions.

If we consider the practical application of iron solutions in the electro-deposition of that metal upon other metallic surfaces, as in the so-called steel-facing of engraved copper plates, for example, I am disposed to give the preference to the following salts for making up iron baths, and if these are prepared with care, and from good materials, there should be no difficulty in obtaining good results from either of them. 1. The ammonio sulphate of iron. 2. Sulphates of iron and magnesia. 3. Sulphate of iron and chloride of ammonium. 4. Sulphate of iron *per se*. To prevent the solutions from becoming oxydized many different substances have been added to iron baths, as glucose (grape sugar), glycerine, &c.; but I am disposed to think, from experiments I made in this direction, that small doses of citric or tartaric acid will be found more effectual, while these vegetable acids have also a tendency to improve the brightness of the iron deposit. Again, in making up iron baths for the practical deposition of the metal, it is often recommended to employ an anode of large surface—that is, considerably larger than that of the article to be coated. I am disposed to suggest, however, that the strength of the solution and density of current should be so regulated that the metal will be deposited freely and uniformly with an anode surface about equal to or, at least, not greatly exceeding that of the cathode. My object in suggesting this is that I have found the metal to deposit well under such conditions from the solutions named, and such being the case, there can be no real advantage in greatly exceeding the limit of anode surface. A solution will, I believe, yield more uniform results and maintain its normal condition for a longer period if a uniform density of current be always maintained, and the liquid kept in such a condition that the iron will freely deposit when the electrodes are of about equal surface. To my mind it is generally a sign that the electrolyte is defective, or the current too weak, when a large anode surface is necessary to obtain a metallic deposit of good quality, and at a proper rate of speed to render the film adherent. In depositing iron from any of its neutral solutions great care should be taken, when lifting the article out of the bath to ascertain how the deposit is progressing, that the film be not exposed to the action of the air for any length of time, since the exposure of a few seconds only would be quite sufficient to form a film of oxide upon the surface, which would effectually prevent the subsequent layer of metal from adhering to the first. We all know, as I pointed out many years since, that metals do not adhere well to their kind when deposited by electrolysis; thus, gold does not firmly adhere to gold, silver to silver, and so on; but this is more remarkably the case in respect of nickel, which I believe cannot be made to adhere to the same metal by any electrolytic method whatever. I have been prompted to make the above observations in the hope that they may in some degree assist in guiding those whose inclination or duties may lead them to engage in the electro-deposition of iron upon other metals.

ALTERNATE-CURRENT ELECTROLYSIS.[1]

BY MM. J. CHAPPUIS AND G. MANEUVRIER.

THE impossibility of producing electrolytic decomposition of sulphate of copper by an alternating current is generally supposed to be an established fact. The absence of all electrolytic phenomena is explained by the assumption that the copper deposited by one current is immediately removed by the other. This negative result is even brought forward as a proof of the exact equality of the two currents. We, however, have been able to justify this explanation by rendering visible the electrolysis of the sulphate, as we have already done in the case of acidulated water.[2] The experiment is, however, somewhat more complex and more difficult to effect. If a concentrated solution of copper sulphate is placed in a voltameter with platinum electrodes, currents having an average strength of 2.5 amperes (which in the case of acidulated water produce an abundant evolution of explosive gas) give rise in sulphate of copper to nothing more than a considerable heating effect. But if the size of the electrodes is reduced to about 6 sq. mm. (0.1 mm. diameter, 20 mm. long), there is both evolution of gas and deposition of copper. Electrolysis succeeds equally well with copper electrodes of the same size. As soon as the circuit is closed, a column of minute gas bubbles instantly ascends amidst a cloud of red-brown powdery copper, whilst the electrodes soon assume the appearance of the freshly reduced spongy metal.

Taking all our experiments together, they seem to show that it is possible to establish a sort of equilibrium between the rate of decomposition and the rate of recombination of the constituents of the electrolyte. Once this equilibrium is attained, there seems to be no further electrolysis, properly speaking. Hence, all things which tend to make the rate of the former predominate over that of the latter will cause the reappearance of electrolytic phenomena, whilst those conditions which tend to make the rate of recombination predominant will cause these phenomena to disappear.

Current density is one of the principal things which tend to accelerate electrolysis. It is evident that if on the one hand we increase the quantity of electricity traversing the electrolyte, while on the other we diminish the surface of the electrodes, we shall cause the rate of decomposition to gain on that of recombination, and tend to produce electrolytic action. It is also easy to understand that both electrodes and electrolyte may greatly affect the rate of recombination by virtue of their chemical and physical properties. Hence the tendency to electrolysis depends upon the nature of electrodes and electrolyte, as shown by our previous experiments. Lastly, it can be foreseen that, all things being equal, the rate of alternation will play an important part in these phenomena. For supposing that the rate of alternation becomes so slow that the electrolytic products of one current have time to disappear, either by direct disengagement or by diffusion, before the products of the opposite current appear, it is obvious that no recombination is possible. In this case each current acts like a continuous current of short duration; thus, the slower the rate of alternation the greater the probability of electrolytic effects, all things being equal, and *vice versa*. We have been able to verify this theory by actual experiment. Employing, as we did, a separately-excited machine, we were able to vary the rate of alternation without affecting the average strength, and, consequently, the average density of the current. We altered the speed of the machine from 1,500 to 2,600 revolutions a minute, thus raising the number of alternations per second from 100 to 173, and by regulating the strength of the current flowing round the field magnets we were able to maintain a constant current. Under these conditions we carried out the two following experiments.

With the machine running at its proper speed of 2,000 revolutions a minute (133 alternations per second), we regulated the strength of the current so as to obtain a state of equilibrium, *i. e.*, a state in which no gas would be evolved in an ordinary water voltameter. We then lowered the speed to 1,500 revolutions (100 alternations a second), and gas was freely evolved at the electrodes. Next with the machine running at 2,000 revolutions and the current regulated so as to produce a remarkable and regular evolution of gas, we increased the speed to 2,600 revolutions (173 alternations a second), and the evolution of gas was immediately arrested. In either case it is possible to counteract the effect of this variation of speed by a proper modification of the current density. Thus, in the first experiment the gases were made to disappear again by increasing the surface of the electrodes; whilst in the second experiment the gas was made to reappear by reducing their surface.

We thus see that speed of alternation and density of current affect the question of electrolysis inversely, so that currents of medium density may give rise to electrolytic effects, provided the alternations are slow enough. It was owing to this that in 1837 de la Rive was able to decompose acidulated water by means of alternate currents from the then recently invented magneto-electric machines. He was able to get explosive gas on large platinum electrodes of eight square centimeters surface, so that the difficulty in his case was to get rid of the gases, while in our case the difficulty was to make them appear. This difference arises from the fact that the machine used by de la Rive gave at the most 50 alternations per second, whilst ours gave at least 100 alternations. From these experiments we shall be able to deduce the numerical laws of the several phenomena and the general rules which ought to guide the use of these currents for this purpose.

In a subsequent communication (*Comptes Rendus*, vol. cvii., No. 2) MM. Chappuis and Maneuvrier give an account of their

1. Translation of a paper by MM. J. Chappuis and G. Maneuvrier, read before the Académie des Sciences. (*Comptes Rendus*, vol. cvii., No. 1.) From The *Electrician* (London).

2. See the *Electrician*, 29th June, p. 237.

investigations into the causes of the spontaneous explosions of the mixed gases given off by alternate current electrolysis, and the means by which they were enabled to avoid this dangerous occurrence. The following is an abstract of this interesting paper:—

"If a voltameter of the ordinary pattern is used in alternate current electrolysis experiments an explosion inevitably occurs when all the liquid has been nearly expelled from the collecting tubes, and it was only after we had taken special preventive measures that we were able to continue our researches. This phenomena was observed by de la Rive as long ago as the year 1837, and also by Bertin in 1857. De la Rive passed alternate currents from an electro-magnetic machine through an ordinary water voltameter, and noticed that the platinum electrodes became coated with a powdery platinum film, and that if they were then introduced into a vessel containing explosive gases an explosion resulted. From this de la Rive concluded that the phenomenon was due to the so-called catalytic action. Bertin decomposed acidulated water by a continuous current from a battery of 50 Bunsen cells, and collected the evolved gases in the same receiver. He observed that the gases exploded as soon as the receiver became nearly full, both when platinum was used for either electrode and when platinum was used as the positive and iron as the negative electrode. With platinum and copper, or with platinum as the negative and some oxydizible metal as the positive electrode, no explosion took place. Bertin attributed the phenomena neither to catalysis nor heating, but to the "polarization of the electrodes" [an explanation which seems to leave a good deal to be explained]. Neither of these theories suffices to account for the facts as observed by us. Like de la Rive we observed the black film, but it has nothing to do with the detonation of the gases, since this often takes place long before the appearance of the film and when using perfectly new electrodes. Like Bertin, we produced explosions with other metals than platinum; but, unlike him, we came to the conclusion that polarization had nothing whatever to do with the phenomenon. For, take a new electrode and fill a bell-glass with the mixed gases, then substitute another new electrode,—the gases explode the moment the current is put on, provided only that the electrode is sufficiently well out of the water. We attribute these explosions to the electrodes becoming incandescent by reason of their progressive emersion from the liquid, increasing as it does the current density and the resistance, and diminishing the cooling effect due to contact with the solution. We have been able to make this incandescence actually visible.

"We take electrodes of platinum, which are placed in a bent tube. One end of the platinum is soldered to the copper wire conveying the current, the other end is soldered to the glass. We have noticed that the end soldered to the glass becomes incandescent at the moment of detonation. One of the electrodes having been broken, an almost invisible point projected out of the glass, and the moment the current was started this projection became incandescent, exploding the glass bubbles as soon as they came in contact with it. Again, if only the tips of the electrodes are allowed to dip into the liquid, incandescence and detonation are the immediate result."

It follows from this that all circumstances which tend to increase the heating effect, such as increase of current density and diminution of electrode surface, tend to accelerate explosion. Thus, with a .5 mm. wire, detonation did not occur until the gas had pushed down the liquid to within 5 mm. of the end of the electrode. On the other hand, with a 2 mm. wire, the explosion took place when the liquid was still 25 mm. from the end. To prevent explosion we keep the electrodes always well immersed in the solution by enclosing them in a conical or cylindrical funnel, at the top of which there is a small straight tube, which carries off the gases to a receiving vessel. This, or any other similar arrangement, is well adapted to obviate all danger in the manipulation of the explosive gases given off in alternate current electrolysis.

THE VOLTAIC BALANCE.

BY DR. G. GORE, F. R. S.

A NEW and simple lecture experiment. Take two small clean glass cups containing distilled water, simultaneously immerse in each a small voltaic couple composed of either unamalgamated magnesium or zinc with platinum, taking care that the two pieces of each metal are cut from the same piece and are perfectly clean and alike. Oppose the currents of the two couples to each other through a sufficiently sensitive galvanometer so that they balance each other and the needle does not move. Now dip the end of a slender glass rod into a very weak aqueous solution of chlorine, bromine, iodine, or hydrochloric acid, and then into the water of one of the cups. The voltaic balance is at once upset, as indicated by the movement of the needle, and may be shown to a large audience by means of the usual contrivances.

The chief circumstance to be noticed is the extremely great degree of sensitiveness of the arrangement in certain cases:— This is shown by the following instances of the minimum proportions of substance required to upset the balance with an ordinary astatic galvanometer of 100 ohms resistance, and with a Thomson's reflecting one of 3040 ohms resistance.

1. *Zinc and platinum with iodine.* With the astatic galvanometer, between 1 part of iodine in 3,100,000 and 3,520,970 parts of water.

2. *Zinc and platinum with hydrochloric acid.* With the astatic galvanometer, between 1 in 9,300,000 and 9,388,185 parts; and with the reflecting one between 1 in 15,500,000 and 23,250,000 parts.

3. *Magnesium and platinum with bromine.* With the astatic galvanometer between 1 in 310,000,000 and 344,444,444 parts.

4. *Zinc and platinum with chlorine.* With the astatic galvanometer between 1 in 1,264,000,000 and 1,300,000,000 parts.

5. *Magnesium and platinum with chlorine.* With the astatic galvanometer between 1 in 17,000,000,000 and 17,612,000,000 parts; and with the reflecting one between 1 in 27,062,000,000 and 32,291,000,000 parts of water.

Every different soluble substance requires a different proportion, and with unlike substances the difference of proportion is extremely great. With solutions of neutral salts the proportion of substance required to upset the balance is large; for instance, with chlorate of potash, a zinc platinum couple, and the astatic galvanometer, it lay between 1 part in 221 and 258 parts of water.

The degree of sensitiveness of the balance is usually greater the greater the degree of chemical affinity the dissolved substance has for the positive metal and the less it has for the negative one.

By first bringing the balance with a magnesium-platinum couple and the astatic galvanometer nearly to the upsetting point, by adding one part of chlorine to 17,612,000,000 parts of water and then increasing the proportion to 1 in 17,000,000,000, the influence of the difference, or of 1 part in 500,000,000,000, was distinctly detected.

ON THE CHANGE OF POTENTIAL OF A VOLTAIC COUPLE BY VARIATION OF STRENGTH OF ITS LIQUID.[1]

BY DR. G. GORE, F. R. S.

THIS paper contains a series of tables of measurements of the electromotive forces of a voltaic couple composed of unamalgamated zinc and platinum in distilled water, and in aqueous solutions of different strengths of the following substances:—potassic chlorate, potassic chloride, hydrochloric acid and bromine. The measurements were made by balancing the potential of the couple by that of a suitable thermo-electric pile (Birm. Philos. Soc., vol. iv., p. 130), through an ordinary astatic galvanometer of about 100 ohms resistance.

The following are the minimum proportions of those substances, required to change the potential of the couple in water:—potassic chlorate, between 1 in 221 and 258 parts of water; potassic chloride between 1 in 695,067 and 1,390,134; hydrochloric acid, between 1 in 9,300,000 and 9,388,185; and of bromine, between 1 in 77,500,000 and 84,545,000 parts.

With each of these substances a gradual and uniform increase of strength of the solution from the weakest up to a saturated one was attended by a more or less irregular change of electromotive force.

By plotting the quantities of dissolved substance as ordinates to the electromotive forces as abscissæ, each substance yielded a different curve of variation of electromotive force by uniformly increasing the strength of its solution, and the curve was characteristic of the substance. As the least addition of a foreign soluble substance greatly changed the "minimum point," and altered the curve of variation of potential, both the curve and the minimum proportion of a substance required to upset the balance of the couple in water may probably be used as tests of the chemical composition of the substance and as means of examining its state of combination when dissolved. By varying the strength of the solution at each of the metals separately a curve of change of potential was obtained for each positive metal, but not for every negative one.

.... IT is exceedingly rare for an absolutely original invention to be sufficiently perfect to be of immediate use.... .—*Silvanus P. Thompson.*

.... For the last four years very little has been done towards improving either the life or the efficiency of incandescent lamps.—*Marmaduke M. M. Slattery.*

.... There is no known reason why a cheap substance may not be found which will act on coal, and develop electric currents in place of heat.—*Willard E. Case.*

.... There is no gainsaying the fact that the transformer system has made tremendous way, and this would never have been the case had not the system possessed merits placing it before all others for the general distribution of electricity.—*J. Kenneth E. Mackenzie.*

1. Read before the Royal Society, June 14, 1888. Abstract.

LIGHTNING.[1]

BY S. A. VARLEY.

ALL who have read the published lectures on the protection of buildings from lightning, lately given by Professor Oliver Lodge, or who have had the advantage of hearing these lectures delivered, cannot fail to have been impressed with the scientific ability and deep learning Professor Lodge has brought to bear on so interesting a study.

Still these lectures seem to me to convey the impression that the behavior of lightning is involved in great mystery, and they have a tendency, I consider, to unsettle men's minds by conveying an impression that lightning discharges instead of uniformly obeying certain defined laws, as believed by Faraday and our older electricians, act irregularly and capriciously.

The feeling with which I rise from their perusal is that of an unsatisfied desire for more complete knowledge, and a wish that I could conveniently repeat Professor Lodge's interesting experiments, for there is an eloquence in the actual performance of an experiment which the fullest description ever fails to convey.

The subject of lightning discharges is one in which I have always taken an interest.

Many years since I devoted a great deal of time to studying its behavior in relation to telegraph circuits. The first observation of real importance was made by me in Turkey, in 1856, when the lightning struck the Constantinople and Varna telegraph circuit.

The submarine portion of this telegraph was connected to Constantinople by about 24 miles of suspended wire, and there were three stations.

The terminal stations were at Constantinople and Varna, and the intermediate one was in the English embassy buildings at Therapia, about 11 or 12 miles from Constantinople, on the immediate shore of the Bosphorus.

The overground wire passed outside the grounds attached to the embassy, and the connection with the embassy telegraph office was made by means of two lengths of submarine cable sheathed with galvanized wire buried in the grounds, and which formed a loop through the telegraph instrument. The total length of buried cable was about half a mile.

Now, as the Therapia station was an intermediate one, it may be suggested that there was no actual necessity for an earth connection there; but for reasons to be presently explained, there was an earth wire led into the office.

When I took over the charge of the circuit, I found this earth connection had been made by means of the orthodox earth plate, and I found also it opposed considerable resistance. I therefore made a soldered connection between it and the galvanized iron wire sheathing of the two lengths of buried cable, thinking, not unnaturally, that a metallic conductor half a mile in length buried in the ground would make a very perfect connection.

The embassy grounds were situated on a subsoil of rock, still there was a surface soil of some depth, and the grounds were well timbered with numerous large trees.

When the hot weather arrived and the ground became, as a consequence, thoroughly parched, I found, to my surprise, the half mile of buried cable made a very imperfect earth connection, and as the river was close at hand, I discarded it altogether and made another earth contact by burying a No. 8 galvanized wire under the esplanade of the Bosphorus and sinking a length of wire in the river.

Morse printing instruments, worked on the single current system, were used in connection with this circuit, and a current starting from Constantinople passed, as indicated by the arrows in the diagram, from the suspended wire through one length of buried cable, through the galvanometer indicator to the key lever, from the key lever through the back contact to the electro-magnet of the relay, through this to the second length of buried cable, and from thence to the suspended wire again on the other side of the loop. The earth wire was connected to a vertical spring mounted on the key board near to the handle end of the key lever, which made a passing contact with it in its downward and upward motion; the effect of the passing contact was to discharge directly to earth the greater portion of the statical charge acquired by the cable every time the battery was closed in the circuit.

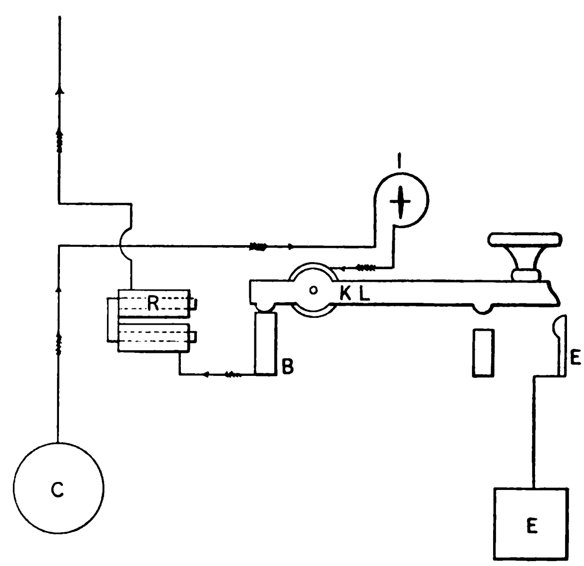
During a thunderstorm which occurred in the neighborhood of Therapia, the lightning struck the overground wire and passed through one length of the buried cable to the galvanometer indicator, leaping across the convolutions of silk-covered wire, burning them up, and bursting the indicator with a report as loud as a cannon, the current then passed on to the key lever which it lifted away from the back contact and depressed the front end of the key by electric attraction until it reached the earth contact, where it became fused and welded to the earth spring by the heavy discharge.

What I wish particularly to direct attention to is, 1. That this powerful discharge passed through one-quarter mile of gutta-percha covered wire buried in the earth without damaging it, showing how difficult it is under certain conditions to make a perfect connection with the body of the earth.

2. That although we know a lightning discharge to be instantaneous, the key lever was moved from a state of rest through a space of nearly one-quarter of an inch, and this movement *certainly* involved time.

I attributed the movement of the key lever to the magnetic polarization of the line wire by the lightning.

In other words, the effect of the lightning discharge was to produce during a very small interval of time a very high state of magnetic potential in the line wire, and the rapid reassumption of the normal unmagnetic condition which followed immediately afterwards developed a current of high enough potential to attract down the key lever, and of large enough quantity to melt and fuse together the key lever and earth spring. The current produced by the act of demagnetization of the line wire was undoubtedly assisted by the statical charge developed in a quarter mile length of buried gutta-percha wire, for although the resistance of the rock underneath the buried cable was so great that the lightning discharge did not burst through it and in this way reach the body of the earth, yet the large mass of semi-conducting matter surrounding the gutta-percha enabled it to receive a sudden charge, and as the iron wire sheathing outside the gutta-percha was a conductor of low resistance, the conditions were favorable for the rapid discharge of the electricity statically accumulated on the inner and outer surfaces of the gutta-percha insulator. The mass of earth and rock performed, in fact, a somewhat similar function to the slab of wood in some of Professor Oliver Lodge's experiments, which acted the part of conductor so far as to permit of the accumulation of a positive and negative charge



E, earth; I, indicator; R, relay; C, Constantinople; B C, back contact; E S, earth spring; K L, key lever.

in the interior of two Leyden jars, the outer coatings of which rested on the slab, and yet at the same time opposed so great a resistance that when a sudden discharge occurred the electricity leaped a space of air instead of passing through the slab.

It should not be, however, overlooked that a No. 16 copper wire coated with gutta-percha (for this was the size of the copper conductor) and only a quarter of a mile in length when considered as a Leyden arrangement was one of very inconsiderable surface, but still I do not think it should be disregarded altogether, and I have a further reason for referring to it, which can be perhaps more fittingly considered a little further on.

On my return to England I experimentally investigated the subject, and the chief conclusions arrived at were described by me in a paper read before the meeting of the British Association at Liverpool in September, 1870. The following passages appear in this paper:—[2]

"It was well known that high tension electricity would leap across a small space of air in preference to passing throughout the length of a coil of wire, and it was stated this arose from the momentary resistance the wire opposes to polarization or magnetization—a resistance probably approaching to infinite resistance during an infinitely small interval of time; and from this cause, even in a vacuum protector, where the pointed conductors are enclosed in an exhausted chamber, the main discharge will leap across a space of air separating the insulated conductor and the earth conductor outside the exhausted chamber, in preference to polarizing the wires entering the exhausted chamber. The

1. From the *Telegraphic Journal and Electrical Review* (London).

2. This paper was published *in extenso* in *Engineer and Engineering* in October, 1870, and an abstract of it was published in the "Transactions of the British Association."

author, when experimenting with electric currents of varying degrees of tension, observed the very great resistance which a loose mass of powder of conducting matter opposed to the passage of electricity of moderate tension; he found with a tension of 50 Daniell cells electricity did not pass through a loose mass of finely divided blacklead or wood charcoal. When the tension was increased to two or three hundred cells, the particles arranged themselves by electrical attraction, making good electrical contact, and formed a bridge by which the electricity freely passed. With a tension of six or seven hundred cells the electricity was found to pass through a considerable interval of the dust met with in rooms, which consists chiefly of silica and alumina, with more or less organic and earthy matters.

"Incandescent matter offers a very free passage to electricity; masses of highly heated blacklead powder were found with six cells to give an average resistance of five units, or about one-sixtieth of that opposed by an ordinary needle telegraph coil, which may be taken at 300 units. These experiments went to show that an interval of dust separating two conductors opposes practically a decreasing resistance to an increasing tension, and led to the construction of the "lightning bridge," which consists of two pointed conductors, enclosed in a chamber, and approached to within one-eighteenth of an inch from one another, and surrounded with finely divided matter consisting of carbon and a non-conducting substance intimately mixed in suitable proportions determined by electrical tests. The reason why a powder consisting entirely of conducting matter cannot be safely employed is, that although it may oppose a practically infinite resistance to the passage of electricity of the tension of ordinary working currents, when a high tension discharge occurs, the particles under the influence of the discharge generally arrange themselves so closely as to make a conducting connection between the two points of the lightning bridge.

"If the effect of lightning striking the wires be considered, it will be seen that the electric discharge passing through the telegraph coils is not momentary, but occupies time. When an insulated telegraph wire is struck, the effect of the discharge is to polarize the wire throughout; after the discharge the wire returns to its normal unpolarized condition; but the cessation of magnetization, although rapid, is not instantaneous, and the effect of the wire reassuming its normal unmagnetic condition will be to develop an electric current flowing in the same direction as the electric discharge which magnetized the wire. The tension of the current developed by the demagnetization will be very high at its first development, and will rapidly afterwards fall to zero. There is, therefore, first the main discharge of electricity, which passes by the shortest route, and does not wait to polarize the coil wires, but leaps across a space of air to the earth conductor as the easier course, followed by a secondary current in the same direction, but occupying time. The tension of this secondary current, although at first very high, is not nearly so great as the lightning discharge, and the greater portion, if not the whole, will pass through the coils, which oppose, when time is given, a much less resistance than the smallest possible space of air; it would, therefore, seem, when telegraph circuits protected by an ordinary protector are struck by lightning, it is to the secondary current, and not to the main discharge, the fusion must be attributed. The fact that the coils of needle telegraphs are more often fused than other telegraphic apparatus was considered to be a strong confirmation that the fusion was due to the secondary current developed by the demagnetization.

"The relay coils used in other telegraph systems have soft iron cores which are rendered magnetic when a current is passed through the coils. A greater amount of magnetism is developed in these cores than in needle telegraph coils, but a very sensible time is occupied by the iron passing from the normal to a magnetized condition. The momentary resistance these cores oppose to magnetization is very great; the demagnetization of the line-wire proceeds, therefore, more slowly; the electricity generated by the demagnetization being of a definite amount, the tension of the secondary current is reduced proportionally.

"The line wire of a telegraph circuit is *only a continuation of the coil wires, and is rendered magnetic by electric polarization in the same way as the coils*, the chief difference being that the magnetism developed in the coils is concentrated in a smaller space.

"When lightning strikes the line-wire of a circuit, in which electro-magnets protected by an ordinary protector are used, it magnetizes the line-wire, leaps the space which separates the points of the protector, and *does not magnetize the electro-magnets*. Demagnetization of the line-wire, which always takes time, and which can be retarded, follows, and the resistance which the soft iron cores oppose to the assumption of magnetization, retards the demagnetization of the line-wire, reducing the tension of the secondary current. In needle-telegraph coils, there being no large mass of iron to be magnetized, demagnetization of the line-wire follows much more rapidly; the secondary current is more intense, and consequently needle coils more often suffer."

I further state in another part of the paper I have quoted from:—"The retardation which the magnetization of an electro-magnet opposes to the *demagnetization* of another one is well known, and is explained in Culley's 'Handbook of Telegraphs,'[1] in connection with the description of C. F. Varley's translating system. The author refers to it because he is most anxious to advance only that which is the result of his own direct experiment, or is based upon well-established laws generally accepted by leading electricians."

The quotations given from my paper of 1870, demonstrate, I consider, that what is now known as self-induction, and on which so much light has been thrown by the researches of Professor Hughes, is in itself no new discovery, and I further think it may be fairly claimed for me that I grasped its significance. Professor Hughes' experiments were all made, I believe, on short conductors. My first observation of it was made on a much grander scale, and I think the conclusion I came to—that it is a consequence of the magnetic polarization of the conductor—is the more correct explanation, and if this be so, then the term magnetic inertia might be substituted with advantage, in my opinion, for the term self-induction, as more correctly indicating the source of the phenomena. Magnetism in its relationship to electric motion I have been disposed to consider, now, for some years, as the analogue of ordinary inertia, for it seems to me to resist the electrical motion of the atoms of matter among themselves inside the conductor in a precisely similar manner as ordinary inertia resists the motion of matter bodily.

In 1862 I made the observation that if a galvanometer were wrapped with two wires side by side of the same gauge and adjusted to have the same resistance, that when a battery circuit was closed through them one of the wires had invariably a greater influence on the magnetic needle than the other.

And I found the only way of producing a perfect differential galvanometer with exactly the same number of convolutions in both the insulated wires was to make them of wire drawn down from the same sample of copper, and this experience led me to commence the construction of apparatus to try experiments on what I called the magnetic moment of metals. I proposed to charge a paper condenser with 500 Daniell cells, and to discharge it through single straight conductors of various gauges and different metals, mounted between upright terminals in the neighborhood of a delicately suspended astatic needle carrying a mirror. I was prevented at the time from carrying out these experiments, and the opportunity has never occurred since. But what I had already learned from my observation of the lightning discharge in the neighborhood of Therapia, and my experimental investigations in connection with it, justified me, I considered, in anticipating that a conductor of small gauge would produce a greater deflection of the magnetic needles than a conductor of a larger gauge. I regarded the difference of resistance of the conductors with the high potential and mode of conducting the experiments as a negligible quantity. My reason for anticipating a wire of small sectional area would produce a greater deflection than one of larger size was that there would be less magnetism developed locally, and therefore there would be more free force to act on needles outside.

I should be glad even now to carry through these experiments; but I am disposed to think that the researches of Professor Hughes and Professor Lodge indicate to a considerable extent what would be the results likely to be obtained.

Some few years ago I had the pleasure of showing Professor Hughes some magnetic experiments, when he immediately demanded of me how I explained the action of a magnet through space. I replied that in my opinion the force was communicated in a precisely similar way as through a bar of iron, in other words, that there was a chain of matter, or some entity equivalent to matter, which connected the magnet, and the body acted upon through what we call space, and I said I ventured to go farther than this and say that where there was no matter there was no magnetism, no electricity, nor force of any kind, and I was glad to find the views I held coincided with those of Professor Hughes. If we assume magnetic inertia to be the analogue of inertia of matter regarded in the mass, then given a similar sectional area and shape in the conductors the magnetic inertia of each conductor would be perhaps expressed in terms of its electrical resistance; or to put it more plainly, if we regard magnetic inertia as the analogue of the inertia of matter regarded in the mass, then the specific resistance of the conductor would possibly represent its weight or resistance to electrical motion.

Iron and the magnetic metals would be the densest of substances if expressed in terms of magnetic instead of terrestrial gravity, and they would not seem to follow the law I have suggested.

Since the above passage was set in type, I have referred to Professor Hughes' presidential address to the Society of Telegraph Engineers, which, I am sorry to acknowledge, I have never given that attention to which its importance deserves, and I find his experiments go to show that self-induction is not related in any way to the specific electrical resistance of the conductors. I have not, however, withdrawn the passage, because I think I am generally correct in my contention that the inertia which is manifested by a soft iron core around which an electric current is cir-

1. Third edition, page 210, published in 1868.

culated, and the inertia manifested in the conductor itself, are referable to a common cause, the only difference between them being one of degree. I cannot help thinking that among our scientists of the present day there is far too great a tendency to elaborate and coin new phrases, whereas the aim should be to simplify and to link all phenomena and apparent anomalies observed to the common cause from which, if we could but see it, they most probably emanate.

The analogy between magnetic and terrestrial gravity appears to me to be so very complete; as an example, I might refer to the well-known fact that if a large mass of matter be suspended in space, a continuously applied force, however small, will, after overcoming the inertia of the mass, set it in motion; so also will a continuous current of electricity develop and maintain much or little magnetism accordingly to the length and mass of the electrical conductor and the mass of iron subjected to its influence.

In all dynamos, but more especially in shunt-wound machines, advantage is taken of this; and in some of the best examples the energy diverted in maintaining the magnetic field, as well as that consumed in the armature, is as low as from 3 to 5 per cent. If the analogy existing between magnetic inertia and material gravity, to which I have directed attention, can be shown to be complete, its scientific importance can scarcely be overrated, as it would place an instrument of research into our hands which would enable scientists to arrive at a fuller knowledge of the nature of gravity, a force, situated as we are in respect to it, so difficult for us to investigate.

Ever since I had the good fortune to discover the dynamo principle in 1866, I have striven to obtain a fuller explanation of it by studying the nature of the forces as a whole.

Our scientific professors appear to me to have been satisfied to accept this discovery without comment, and to regard the matter as explained when they say it is simply the conversion of one force into another. No one seems to have cared to ask the question how it is that by the expenditure of mechanical force in a machine, a fulcrum can be developed in the machine itself which resists the motion of the machine with a force proportionate to that which has created it, and accounts for such resistance by transmitting its equivalent in the form of energy through an electrical conductor.

In the discussion at the Institution of Civil Engineers, in January, 1878, which followed the reading of Messrs. Higgs and Brittle's paper, I called attention to this point, and stated, I attributed the creation of electrical energy in a dynamo to magnetism being a force possessing inertia, and electricity being a force having little or, as I believed, no inertia. That it was the inertia of magnetism which created the fulcrum, and as a consequence of this inertia, when a dynamo was in action, electricity was developed *instead* of magnetism.

I stated I was led to take this view from an observation made shortly after I had constructed the first self-exciting dynamo.

I had designed a magneto step-by-step alphabetical telegraph, in which simplicity of mechanical construction was obtained from the employment of a very powerful field produced by permanent magnets, and I observed there was perceptibly very much less resistance to the revolution of the handle when the circuit was closed, and electricity consequently developed, than when the circuit was opened and no force was being transmitted.

At the first blush, the fact that less force was being consumed when electric force was being transmitted appeared to be very anomalous; but after thinking over the matter, and sleeping on it for a few nights, I obtained the key to the solution of the problem, viz., that when the circuit was open I was magnetically polarizing the armature cores and overcoming the inertia of magnetism, which may be likened to transmitting a given quantity of force through a circuit of very great resistance, and when the circuit was closed I was developing, in place of magnetic polarization electricity, a force having but little if any inertia, and transmitting it through a circuit of very moderate resistance. When currents are developed by an alternating machine, the iron cores of the revolving bobbins in their passage between the opposite magnetic poles through which they pass in succession, if magnetized at all, are magnetized only to a small degree, electricity being developed instead of magnetic polarization. A little reflection will show it cannot be otherwise, for were magnetism developed in the revolving armatures, the force would be consumed in the machine itself, and there would be no energy to be transmitted beyond the limits of the machine.

I would here point out what is *commonly* termed the conversion of one force into another is not work, and consequently does not consume energy. Were it possible to obtain conductors having no electrical resistance, then the whole of the mechanical force consumed in giving motion to the machine would be transmitted in the shape of energy, and no force whatever would be absorbed after the magnetic inertia had been overcome in keeping up the motion of the vehicle or medium through which the energy is transmitted. I have said in the sentence immediately above, what is *commonly* termed the conversion of energy, for I am disposed to doubt whether there is such a thing as the conversion of force of one kind into force of another kind. I am disposed to attribute what is termed the conversion of force to the balancing of one force by another force, or the balancing one form of energy by another form of energy, and it is in such matters as these that mathematical science is so misleading.

To the mathematician energy is an elementary entity, and when energy at one end of the chain disappears and its equivalent is manifested at the other end he regards it as a full and complete explanation.

I may explain what I mean, perhaps, more clearly by a familiar illustration. A customer goes into a shop to purchase a joint of meat; the butcher places the joint in the scale pan and balances it by means of a weight. Expressed in terms of gravity the meat and the weight are the equivalent of one another, and in a mathematical equation they are convertible terms; but I think it is quite possible, from the customer's point of view, they are not one and the same thing, and he would not be satisfied if the butcher were to send home the weight in place of the meat.

The development of electricity in a dynamo I regard as being produced in a somewhat analogous manner to what would occur if a mass of matter were bombarded with bullets discharged from a rapidly firing machine gun; the motion of the bullets would be arrested and converted into heat. The simile would be more complete if we assume the revolving armature to represent matter bombarded on opposite sides, and the field magnets as matter bombarded on one side. I cannot resist the temptation to say a few words in respect to the Pacinotti armature in reference to its bearing to magnetic inertia, for I think it has never been done justice to in scientific treatises, nor does it seem to me that its *modus operandi* has been wholly grasped by our scientists.

I regard the Pacinotti armature in its theoretically more perfect form of the Gramme ring as being the most beautifully complete of scientific inventions. What I have never seen explained nor even suggested is the fact that both the magnetic as well as the electrical polarization developed in one part of the ring is balanced by that developed in other parts, consequently there is no force consumed in the magnetization of the armature, and it may be revolved in an active magnetic field, providing the collecting brushes are raised without consuming any force whatever; and, further, the commutation of the currents developed in alternate direction in the coils of the armature is performed in a perfect and natural manner by the revolving ring, which is, in fact, its own commutator. In an alternating current machine the magnetic polarization that occurs in the armature cores is so much force diverted and lost.

What takes place when a Gramme ring having no electrical circuit is revolved in an active magnetic field is very similar to what occurs when a disc is revolved rapidly, the particles of matter composing the disc are put into a state of stress by what is very unscientifically termed centrifugal force, for it is simply a consequence of continuously acting on force (which can only move in straight lines) by a second force and so altering its direction that the force developed on one side of the centre of motion is in all parts of the disc balanced by the force on the opposite side being in the reverse direction, and, therefore, the disc as a whole is in a state of equilibrium, although the matter composing it is more or less in state of stress.

(*To be continued.*)

ON THE TESLA ALTERNATING CURRENT MOTOR.[1]

BY J. SWINBURNE.

THE account of Mr. Tesla's invention has received such attention from the technical press, and appears to have satisfied so many people that the problem of alternating current motors is solved, that a short investigation of the subject may not be amiss.

The problem of alternating current motors may be divided into two distinct parts—to make a motor that will start, and to make a motor that will work with varying loads, preferably with constant or nearly constant speeds, but certainly with reasonably high efficiency in each case. As those who are accustomed to the usual way of treating dynamo problems will perhaps find a little difficulty in following Mr. Tesla's description, an attempt will be made to describe his apparatus another way.

Suppose an alternating current dynamo, such, for instance, as the Westinghouse, were taken, the armature has, roughly speaking, only half its periphery covered with wire. If another circuit were wound on, filling up the air spaces, it would also give an alternating current if it had its own collectors, but this alternating current would be a quarter of a period behind the other. The same effect would be got by rigidly coupling two alternate current machines together so that one is a quarter of a period in advance of the other—that is to say, one has its coils in a maximum field when the others are in their minimum field. The simplest form of such a motor would be an ordinary drum armature wound with two coils at right angles, each coil having its own pair of collector rings. This is the example taken by Mr. Tesla. The magnets, of course, are supposed to embrace a quadrant each, instead of about 150 degrees, as is usual in continuous current

1. From the *Electrician* (London).

machines. For simplicity we will suppose the generator to be made up of two ordinary alternating current machines, coupled rigidly together as described, with two pairs of conductors, each with its own alternating current, these currents differing by a quarter of a period. If a motor is made up in a similar way by coupling two alternate current machines together, if once started it will run in exactly the same way as an ordinary alternating current motor, having all its advantages and disadvantages, with the addition that it needs two sets of leads and a special generator. Its efficiency is the same as an ordinary motor, and it will synchronize in the same way. Of course it will not start.

Suppose now that the alternating motor is varied in construction so that the armatures are stationary, the effect will be just the same. A synchronizing motor will be obtained which is not self-starting. Instead of this Mr. Tesla uses what he calls a fixed field magnet with a rotating field and rotating armature in his motor, but we may perfectly correctly call it a fixed armature and rotating field magnet. The armature is outside the field magnet, and may be looked upon as a Gramme ring wound with four coils, the opposite coils being pairs, so that there are two circuits. One is connected to each pair of leads. The direction of magnetization is thus made to revolve just as in any alternate or direct current machines in which the armature is fixed and the field revolves, such, for instance, as the Ayrton and Perry motor or new Siemens dynamo. So far the only result is no better than can be got from machines already known.

As to the exceedingly ingenious method of starting, suppose in an ordinary dynamo an armature is revolved, having some short-circuited coils, the armature resists the motion owing to the currents induced. The armature is revolving, and the direction of magnetization is fixed; but, as motion is relative, we may say that the direction of the magnetization and the closed coils are moving relatively to each other. This relative motion is opposed by the currents induced in the coils. Now, if Mr. Tesla winds some closed coils on what he calls his armature, and what is here called his field-magnet, when the direction of magnetization moves round relatively to the closed coils, currents are induced which tend to make the field magnet revolve.

This ingenious method of making it start is the only advantage Mr. Tesla's motor possesses. In the synchronizing form the closed coils of the field magnets are used till the proper speed is attained, when the machine falls into step, and the exciting current is switched on, so that they become the field magnet coils in the ordinary sense. In another form the whole motive power is supplied by these closed coils, so that the machine does not actually synchronize, but goes slower at heavy loads.

Taking the first form, or synchronizing motor, we get a self-starting motor, but it needs an exciter, and needs also a special dynamo to drive it, with two circuits, involving three or four leads. In the second form the revolving part cannot be so well described as the field magnet, because it is excited entirely by the armature. Of course an ordinary direct current dynamo will work as a motor without any field current if the brushes are put forward, the field being then excited by the armature current; but to make such an arrangement efficient, apart from the question of sparking, which does not now concern us, the armature would have to be designed so as to magnetize the field strongly. In Mr. Tesla's arrangement this is impossible unless the machines are of enormous size. This difficulty would be lessened by making both the fixed and revolving parts on the Pacinotti principle. Instead of using two closed coils on a smooth core, there would also be an advantage in simply encasing the armature in solid copper.

The low efficiency is not at all the chief objection to the scheme. The whole arrangement is unpractical, as it demands special alternate current generators and leads. There are several ways of starting alternate current motors. The exciter may have laminated field magnets, and may be put on the alternate current circuit to get up the speed, as already proposed by the writer, or a small secondary battery may be used in connection with the exciter, which will start the whole system. It would never be worth while to put down special dynamos and special leads just to use a motor that will start, and that has no other advantages. The two circuits would be useless for other purposes. The transformer proposed by Mr. Tesla must be very inefficient. It has consequent poles revolving, and has thus an open magnetic circuit. It would be better to use the two alternating currents separately, putting some of the transformers on one circuit and some on the other; but if two circuits are to be used it would certainly be cheaper to use a direct current for the motors, and have them self starting, self-regulating, and efficient. Until Mr. Tesla can produce a motor which will work on alternate current circuits as they are, and do that efficiently even with varying loads, and without difficulty in starting, he can hardly be said to have solved the problem. With the ingenuity he has already shown no doubt he will do it soon, but he cannot be said to have done it yet.

.... The electric motor absorbs electricity in nearly a direct ratio with the work put upon it, giving practically the same efficiency with light and heavy loads.—*Frank J. Sprague.*

ENGLISH VIEWS ON SOME RECENT PATENT DECISIONS.

THE RECENT ELECTRICAL PATENT CASES.[1]

The judgment delivered by Mr. Justice Kekewich on Monday, the 9th inst., in the action between Messrs. Gaulard & Gibbs and Mr. Ferranti, is tantamount to a declaration that there shall be no monoply in the distribution of electrical energy from a central station by means of alternating currents. Had the verdict been given in the opposite sense, it would, strictly speaking, not have precluded electrical distribution by alternating currents as a general system, but only that particular arrangement in which transformers are used. As, however, only this arrangement is, in the present state of our knowledge, of any practical advantage, the monopolizing of transformer distribution would in effect be equivalent to the monopolizing of alternating currents for central station work, and there can be little doubt that such a monopoly would have formed a further deterrent to the electric lighting industry, which is already struggling with enough difficulties, not only legal, but also technical and commercial. However much we may sympathize with Messrs. Gaulard & Gibbs, whose pioneering work in this direction has thus failed to obtain legal support, we cannot disguise the fact that, by breaking down the monopoly which they attempted to establish, Mr. Ferranti has rendered an enormous service to the electrical engineering profession at large, and the decision of Mr. Justice Kekewich is consequently received with satisfaction by the majority of electric light engineers. It might perhaps be urged that to give Messrs. Gaulard & Gibbs the exclusive right to transformer distribution need not necessarily retard the progress of electric lighting, for these patentees would find it to their own interest to grant licenses for certain localities. It would obviously be impossible for the owners of the Gaulard & Gibbs patent themselves to carry out every installation in Great Britain which may be put down on their system; and to obtain the greatest benefit from the control of the patent they would naturally look to the granting of licenses, fixing their fees sufficiently low to induce the largest possible number of consulting engineers to recommend it, and contractors to carry it out. In theory such an argument is plausible enough; but in practice it is entirely fallacious. The fallacy lies in the assumption that one and the same system of distribution is applicable to all localities, and that in any one locality only one system need be adopted. The great object of a company starting an electric light station is to earn money by the sale of electrical energy, and to attain this object they must be prepared to supply this energy in exactly that form or variety of forms demanded by their customers. An electric light company should not restrict itself to one particular system; it should, if the demand is sufficiently great, be prepared to supply electricity in any form, whether by the direct low tension system, the direct high tension arc light system, by accumulators, or by alternate current transformers. All these systems are useful in certain cases, and to restrict the choice of system in any way is equivalent to curtailing the earning power of the station. If Messrs Gaulard & Gibbs had a monopoly of distribution by transformers they would have to parcel out Great Britain into districts, to be taken up and worked under license by different electric lighting companies. There would be endless complications about overlapping of districts and want of coincidence between the boundary as defined by the Gaulard & Gibbs' license and that imposed by municipal and other local considerations. The consulting engineer, when advising his clients whether to adopt the Gaulard & Gibbs' system or not, would have to consider a variety of points quite foreign to the scientific and technical parts of the problem, and to escape incurring responsibility in matters outside his professional control, would, in most cases, advise to leave the monopolized system alone, and adopt one in which his hands would be free to do the best he can for his clients. We may, therefore, set aside the argument that a monopoly in distribution by transformers would not necessarily restrict the development of central station lighting.

On the other hand, we doubt very much whether the loss of their patent will in reality prove disadvantageous even to Messrs. Gaulard & Gibbs themselves. To them undoubtedly belongs the merit of having been the first to show distribution by transformers in practical operation in England, and this fact cannot fail to invest their company with a considerable amount of prestige. There will be no lack of work for a company who is so favorably situated, and it is quite possible that by doing this work the company will fare better than if they had succeeded in establishing their monopoly.

Messrs. Gaulard & Gibbs will, of course, appeal against the decision of Mr. Justice Kekewich. Patent cases are seldom abandoned after having passed the first tribunal; and as the case will thus again come before the courts, we shall abstain from discussing the validity of the claims in the Gaulard & Gibbs' patent at present. As far as the case has already been argued in court it affords, however, a very instructive illustration of the masterly way in which apparently intricate and abstruse problems are

1. From *Industries* (London) July 20.

grasped and dealt with by legal minds. There are many trained electricians to whom questions connected with alternating currents and transformers present almost insuperable difficulties, yet the judge and counsel appeared to have thoroughly mastered the subject so far as this was necessary for a just appreciation of the various patent specifications which were put in. To a lay mind, the strongest argument in favor of the revocation of Messrs. Gaulard & Gibbs' patent would naturally appear to be that based on anticipation by Jablochkoff, Harrison, Fuller, Bright, Deprez, and others; and as regards Deprez, Mr. Aston conceded that his clients would not raise any objection if Mr. Ferranti worked according to that specification. Now the specification describes a system in which a machine produces a low tension current of large quantity which is converted at the station by means of a transformer into a high tension current of correspondingly diminished quantity. This current is sent out to the district to be lighted, and then reconverted into a low tension current. Curiously enough, this is precisely the system which Mr. Ferranti is adopting for his large central station at Deptford, and, according to Sir William Thomson, it is probably the best system which could be adopted for large stations, as thereby the great difficulty of insulating for excessively high tensions in the dynamos is overcome. Whatever may have been the weight of arguments based on the question of anticipation, Mr. Justice Kekewich did not enter into this part of the case, but gave his decision simply on the Gaulard & Gibbs' patent as amended, and as if it stood alone.

He said that a combination claim can only be upheld if each of the elements entering into the combination is fully and specifically described; but as there is nothing in Messrs. Gaulard & Gibbs' specification to show what special form of secondary generator is meant, and as indeed there is nothing special about their secondary generator, the claim is bad.

Whilst thus Mr. Justice Kekewich last week decided that there shall be no monopoly in alternate current distribution, Mr. Justice Kay, on Monday of this week, came to a similar decision in regard to glow lamps. We have from time to time reported the proceedings in the famous case of Edison and Swan *vs.* Holland, which has occupied the court for 22 days, and is probably the longest patent case on record. It will be remembered that on the suggestion of the judge a series of experiments were made to demonstrate practically certain of the statements made by expert witnesses, and to show whether a commercially successful lamp could be made by following the directions given in Edison's specification. Having taken time to consider Professor Stokes' report describing these experiments, Mr. Justice Kay delivered judgment on Monday last. This judgment shows perfect mastery over the whole subject, and is in itself a most interesting and complete summary of the development of the glow lamp up to the year 1878.

His Lordship decided broadly that Edison was not the inventor of the incandescent lamp, that Edison did not discover any useful principle, that the only thing he did, or attempted to do, was to make a carbon thinner than those then in use. He also decided that the patent was bad because it was of no commercial use. Edison lamps made under that patent were never sold, and the so-called Edison lamps were made under subsequent patents, not under that in question. The patent was also bad because the specification did not give instructions by which a lamp could be made, and also because it gave misleading instructions or misdirections. To say that Edison invented the incandescent lamp was monstrous. Neither Edison, Swan, Lane-Fox, nor anyone else invented the incandescent lamp. It is a gradual growth. It has developed by stages, generally slow, beginning about 50 years ago. Latterly it has developed more rapidly owing to the impetus given to electric lighting by the advent of commercial dynamo machines, and it will now develop still further. Many men have worked out important details, and Edison deserves honorable mention among them, but that is all that can be said. The daily press appears to regard Edison as the one and only electrical inventor, but such views find no sort of reflection in technical circles. We are glad of this decision, because it breaks down one of many prejudicial monopolies. The Edison patent, though by far the most important, was not the only one which figured in this action. The defendants were also sued on the Cheesbrough patent. This was said to cover the process of "flashing" now used by all incandescent lamp makers. This process is of great commercial utility, as it admits of making the lamps of any desired resistance. The defendants argued that it was invalid on several grounds, but Mr. Justice Kay held that the defendants infringed it, and that it was a valid patent.

We do not intend to go deeply into the legal questions involved in the action, nor do we think it advisable to discuss the complicated technical evidence given; but we may deal with the broad results of the action, and their effect on the electric lighting industry. The result of the double decision is this: Anyone can now make lamps, but he is debarred from using a process of great commercial convenience. If both patents had been declared invalid, no doubt there would have been a flood of cheap lamps, as it is needless to say modern lamps can be made for about a shilling each, or less. It might have taken a little while before English makers, except the Anglo-American Brush Co. and Messrs. Woodhouse & Rawson, could manufacture so cheaply; but the various foreign, and perhaps American lamps, could have been put on the market at once. The result of the Cheesbrough decision will be to prevent the importation of lamps, as it will not be worth while for a foreign maker to overcome the difficulties in making unflashed lamps commercially. These difficulties will also deter small makers in this country, so we may expect the manufacture will still remain in the hands of a few. Though this will prevent a flood of cheap lamps, it is probable that competition will improve lamps gradually and will cheapen them in time. It must be remembered that cheap lamps or better lamps do not mean only a saving in lamp bills, but also the cheapening of electric lighting; for lamps can then be run brighter, so that more light is obtained to the horse-power; that is to say, the takings of a station may be enormously increased without any increase of plant or labor. A very small improvement in lamps would convert a loss into a large profit in a central station.

Of course the Edison-Swan company may appeal as to the Edison patent, and the defendants may appeal as to the Cheesbrough. We think, however, that nothing would be gained on either side, as the Edison patent seems hopelessly invalid, and the Cheesbrough patent has had three judgments in its favor.

INFLUENCE OF THE CHEMICAL ENERGY OF ELECTROLYTES UPON THE MINIMUM POINT AND CHANGE OF POTENTIAL OF A VOLTAIC COUPLE IN WATER.[1]

BY DR. G. GORE, F.R.S.

By means of a zinc-platinum voltaic couple in distilled water, with its electromotive force balanced by that of a suitable thermo-electric pile[2] (Birm. Philos. Soc. Proc., vol. iv. p. 130), the effect of several groups of chemical substances upon the potential of the couple was examined. Measurements were made of the electromotive forces of a series of strengths of solution of each substance, and the results are given in a series of tables.

The minimum proportions of substance required to change the potential of the couple in water were as follows:—

Potassic iodate.	Between	1 in	443	and	494
" bromate.	"	1 "	344	"	384
" chlorate.	"	1 "	221	"	258
Potassic iodide.	Between	1 in	15,500	and	17,222
" bromide.	"	1 "	66,428	"	67,891
" chloride.	"	1 "	695,067	"	704,540
Iodine.	Between	1 in	3,100,000	and	3,521,970
Bromine.	"	1 "	77,500,000	"	84,545,000
Chlorine.	"	1 "	1,264,000,000	and	1,300,000,000

On comparing these numbers we find that the proportion of substance required to upset the voltaic balance was largest with the oxygen salts, intermediate with the haloid ones, and least with the free elementary halogens. It was smaller the greater the degree of chemical energy of the substance; thus it was about 400 times less with chlorine than with iodine. And it was smaller the greater the degree of freedom to exert that energy: thus it was about 5,416,000 times less with free chlorine than with potassic chlorate, or 1,570,000 times less than with the combined chlorine of the chlorate, and about 185 times smaller than with potassic chloride, or 88 times less than with the combined chlorine of that salt.

The order or curve of variation of potential by uniform increase of strength of the solution was different with each substance, and was apparently characteristic of the body in each case. A great number of such representative curves might be obtained with a zinc-platinum or other voltaic couple in different electrolytes.

POINTERS.

.... The current is created by means of a copper brush working against the surface of the commutator; revolving at the rate of 1,100 revolutions a minute.—*New Orleans Paper!*

.... A man who writes good common-sense articles, and signs his name to them, is obtaining a reputation that will be of great value to him. Everybody who reads his writings becomes acquainted with the writer, even though they never met personally.—*Anonymous* (!)

.... The state legislatures caught up the cry [Bury the wires!] and with the usual readiness of legislators to act upon matters about which they knew nothing whatever, an act was passed requiring that all the wires in New York city should be placed underground before November 1, 1885. They might as well have decreed that on and after that date all the transatlantic travel should be by means of balloon, or that New York should have an honest city government.—*Professor Wm. A. Anthony.*

1. Read before the Royal Society, June 14, 1888. Abstract.

2. This instrument is manufactured by Messrs Nalder Bros., Horseferry road, Westminster, London (Eng.).

CORRESPONDENCE.

NEW YORK AND VICINITY.

The Board of Electrical Control following up "Dead Wires."—The Attorney-General Declines to take Special Action against the U. S. Illuminating Co.—Execution by Electricity.—$10,000 a Year for Gas at the Brooklyn Jail; Electricity Recommended by Supervisor Quintard.—Rumors about Western Union.—The National Electric Light Association.—The Pacific Postal Telegraph Cable Co.—A New Board of Directors.—Mr. Levi P. Morton retires.

THE board of electrical control has addressed to the board of aldermen and the commissioners of public works a letter, based on the recommendation of a coroner's jury, in which the necessity for prompt action in the matter of enforcing the rules and regulations adopted by the subway commissioners is forcibly urged. The crying and imperative need for protection from the danger to life and limb with which the public are now threatened from dead poles and wires, and poles and wires which have never received the proper sanction of the authorities, is duly set forth, as is also the advantage to be gained by summary action on the aldermen's part. Following on this are signs of vigor that look as if the authorities had at last got down to business. Inspector McGuinness, with a dozen able-bodied men well supplied with ropes, picks and saws, and supplemented by a couple of wagons, began work on North William street on the 21st. inst., and soon had a number of the "dead" poles on their way to the corporation yard. Twenty-six poles along North William, Houston and Sixth streets were removed, and the work is to go on.

Attorney-general Tabor has denied the application of commissioner Gibbens, of the board of electrical control, to have him bring special action against the United States Illuminating Co., for failing to comply with the provisions of chapter 716, laws of New York, relating to electrical conductors. The attorney-general holds that the law provides a remedy.

At the inquest on a young man who was killed in a Bowery clothing store through touching an arc lamp, the jury's verdict censured the United States Illuminating Co., for having the lamps in a position that makes them dangerous to the public, and for not having their lamps and wires insulated. It also recommends that a corporation ordinance be passed compelling all electric light companies to insulate their lamps and wires, and also to insert a clause in their contracts with patrons, warning them not to touch the lamps or wires.

In view of the fact that in about four months the new law on execution by electricity goes into operation, any additional light on the subject of the nature and effect of electric currents has considerable interest. Mr. Harold P. Brown's experiments on dogs at Columbia College, while demonstrating very clearly the inadvisability of allowing the electric current to be used without due protection to the public, have also shown that as a means of taking life it may sometimes be effective. Regarding the possibility of mutilation, which is a matter upon which the adoption of electricity for executions may eventually depend, we have not yet sufficient data on which to form an opinion. It is not unlikely that before long scientists may extend their investigations in this direction; indeed, considering its importance it is desirable that a series of experiments under official auspices should be carried out without delay.

Supervisor-at-large Quintard, of Kings County, has sent a communication to the board of supervisors, calling attention to the expense of supplying Raymond street jail in Brooklyn with gas. The gas bills for the jail amounted to $8000 in 1887, and this year will probably reach $10,000. The supervisor recommends the substitution of electricity for gas, the county to use its own plant.

We hear nothing more of the sensational rumors with which Wall street was rife in the early part of last month, concerning Mr. Gould's intended sale of the Western Union Co.; but the public is quite prepared for new developments in regard to telegraphic matters in this country.

The National Electric Light Association this week will bring together a large number of representative electricians, and from the list of expected contributors, the papers to be read will be of great importance and interest, and valuable discussion may be looked for.

At the annual meeting of the Pacific Postal Telegraph Cable Company's stockholders, held at No. 1 Broadway, Mr. Levi P. Morton, who has been a member of the board of directors for years, sent in his resignation, and the following board was chosen for the ensuing year: John W. Mackay, of California; William C. Van Horne, Charles R. Hosmer, and Sir George Stephens, of Montreal; Albert B. Chandler, Henry Rosener, Hector De Castro, Edward C. Platt, and George G. Ward, of this city. Officers were re-elected as follows: president, John W. Mackay; vice-president, Hector De Castro; secretary, John O. Stevens; treasurer, Edward C. Platt; general manager, Charles R. Hosmer.

.... The fellow who is out of a job doesn't like monopolies. If his job is that of running a monopoly, or profiting by it, he is better pleased with it.—*The Millstone.*

PHILADELPHIA.

The New Edison Station.—The Keystone Light and Power Co. —Appeal to the Courts against City Councils.

THE Edison Electric Light Co.'s building, now in course of erection on Sansom street above 9th, and of which a complete description was given in a previous letter, is rapidly nearing completion, and bids fair to bear favorable comparison with any building for electric lighting purposes, in the country.

The indiscriminate tearing up of the streets of the city for the purpose of laying electric light and telephone conduits, may receive a sudden check now that the Keystone Light & Power Co. has gone into court to compel the city councils to give it a hearing. After months of fruitless effort the Keystone company has been obliged to adopt this course, because councils have always turned a deaf ear to the petitions of the corporation for an extension of its privileges.

The Penn Electric Light Co., which has a practical monopoly of the streets of the city for electric lighting, has bitterly fought the Keystone company at every point, and has prevented it from getting its ordinance considered favorably by either the board of highway supervisors or councils.

In order to reveal the secret of the opposition against it the friends of the Keystone company in councils succeeded in having a special committee appointed to investigate the general subject, but nothing ever came of it. The action of the Keystone company is somewhat novel, inasmuch as it is generally supposed by councilmen that councils have control of the streets, and they are anxiously awaiting the action of the court.

The Penn company has control of all the desirable territory in the city, and it rents out these privileges to the Edison and other companies at an immense profit. The Edison company has to depend upon the legal position of the Penn company for its franchise, so that the settlement of the matter will be awaited with some anxiety by those most interested.

PHILADELPHIA, August 18, 1888.

BOSTON.

The Association of Edison Companies meet at Nantasket.—Output of Telephones.—American Bell Telephone Co.'s Earnings.—Reports of the New England and the Erie Telephone Companies.—Telephone Lines Disturbed by Street Railway Currents at Quincy, Mass.—Advantages of the Police Signal System.—Fire Alarm Boxes in the State House.—The Westinghouse Suit against the Sun Electric Co. for Infringing the Gaulard and Gibbs Patent Dismissed.—The Thomson-Houston Regulator Patent Sustained by Judge Colt.—The Malden Electric Light Station, Bangor, Me., to have a Street Railway at last, and it is to be an Electric Road.—Electric Street Railway Notes.—The West End Co.—Mr. Whitney fully convinced of the Superiority of Electric Traction.

THE association of Edison Electric Illuminating companies, comprising those in the United States and Canada, met at Hotel Nantasket on the 8th inst., in semi-annual session, John J. Beggs, of New York, presiding. The following-named officers were elected: president, John J. Beggs, of New York city; vice-president, C. P. Gilbert, of Detroit, Mich.; secretary, J. H. Vail, of New York city; treasurer, Wilson S. Howell, of New Brunswick, N. J.; executive committee, A. L. Smith, of Wisconsin, F. R. Upton, of Harrison, N. J., C. L. Edgar, of Boston, Thomas P. Merritt, of Reading, Pa., R. M. Jones, of Laconia, Wis. Improvements, present and prospective, in lighting and power, were discussed at some length, and the evening was devoted to the reading of a paper, illustrated by the stereopticon, on the subject of "Protecting Electric Light Circuits from Lightning," by W. J. Jenks, of New York city. The meeting was continued during the 9th.

The statement of the output of telephones by the American Bell company for the month ending July 20, is as follows:

July.	1888.	1887.	Increase.
Gross output	4,485	4,345	140
Instruments returned	2,010	3,196	*1,186
Net output	2,475	1,149	1,326
Dec. 21 to July 20—			
Gross output	34,046	33,008	1,038
Instruments returned	12,886	14,310	*1,424
Net output	21,160	18,698	2,462

*Decrease.

Bell telephone earnings for June are said to show an increase of 60 per cent. over June, 1887, while the gain for July is placed at over $100,000 in comparison with the same month last year. Earnings now are stated to be at the rate of 28 per cent. per annum on Bell stock.

The New England Telephone Co. has declared a quarterly dividend of 75 cents per share, payable August 15, to stock of July

31. The books will be closed from August 1 to 14, inclusive. The statement of operations for the quarter ended June 30, is :

	1888.	1887.	Increase.
Gross	$280,116	$251,782	$28,334
Expenses	189,791	178,588	11,203
Net	$90,324	$73,194	$31,139
Construction	23,249	....	23,249
Surplus	$67,075	$73,194	*$6,019
Since Jan. 1.			
Gross receipts	$546,444	$491,690	$54,754
Earnings	380,025	343,949	36,076
Net earnings	$166,319	$147,641	$18,678
Construction	26,519	3,555	22,969
Surplus	$139,800	$141,091	*$1,291

*Decrease.

The regular quarterly dividend of 1¾ per cent. has been declared by the Erie Telephone Co. The statement of the operations for the first quarter of the fiscal year is as follows :

QUARTER ENDED JUNE 30.

	1888.	1887.	Increase.
Gross earnings	$163,662	$146,419	$17,243
Expenses	104,569	97,906	6,663
Net earnings	$59,093	$48,513	$10,580
Construction	9,870	8,657	1,213
Surplus	$49,223	$39,856	$9,367

SUBSCRIBERS.

Added—	1888.	1887.	Increase.
Quarter	204	276	*72
Total connected—July 1	10,747	9,998	749

*Decrease.

Telephone subscribers at Quincy complain that it is almost impossible to use their instruments after nightfall when the electric street lights are turned on. The wires of the telephone company and of the electric light company are run for the most part upon the same poles, the result being that the heavy current on the light wire produces a loud buzzing noise on the telephone circuits.

Irrational persons are often heard to say that a police officer can never be found when wanted. At times, as is admitted by the superior officers of the police department, there appears to be ground for the statement. This will not be the case any longer, thanks to the police signal system by which an officer is compelled frequently to report by signal to the station while patrolling his route. There can be no shirking of duty—every patrolman being constantly under the thumb, so to speak, of the officer in charge of the station house.

The sergeant-at-arms has had placed in the State House seven alarm boxes, which are put in and connected with the city fire alarm telegraph by the Gamewell Auxiliary Fire Alarm Co. Every floor of the building is covered. The annual expense to the state is very small—less than $50.

Judge Colt, of the United States Circuit Court, has dismissed the plaintiffs' bill in the case of the Westinghouse Electric Co. *vs.* the Sun Electric Co., which was a suit brought to enjoin the defendants from infringing letters patent granted October 26, 1886, to George Westinghouse, Jr., assignee of Gaulard and Gibbs, for the method of electrical distribution by alternating currents and converters.

A decree for an injunction and an account has been given in the United States Circuit Court in the suit of the Thomson-Houston Electric Co. *vs.* Citizens' Electric Light Co. *et al.*, brought to recover damages for an alleged infringement of letters patent No. 238,315, granted to Elihu Thomson and Edwin J Houston, March 1, 1881, for improvements in current regulators for dynamo-electric machines. Defendants used the Fuller-Wood regulator, which was manufactured by the American Electric Manufacturing Co.

By invitation of the officers of the Malden Electric Light Co., a number of persons recently inspected the station which has been erected for the company on Centre street, Malden. The station occupies an excellent building, and is equipped with everything necessary to conduct the electric lighting business successfully. The company is now supplying 300 arc lights for the streets and stores of Malden, Melrose and Everett, and has capacity for supplying 300 more arc lights. It is also supplying for Malden, Melrose and Everett, 400 incandescent street lights, and has power to produce 400 more. J. S. Bartlett, of Lynn, is president of the company, and A. E. Bliss, of Malden, is superintendent.

The electric light company in Salem is supplying 250 arc lights and from 300 to 350 incandescent. The city has 145 electric street lights.

Something is going to happen in Bangor that will astonish the natives more than anything that has occurred since the electric lights first banished Egyptian darkness from its queer old streets, and when it does happen many of the older settlers are expected to take to the woods. For 54 years this has been a city, and yet in all that time, unless one had a stable of his own, there has been no way of getting about the streets except by walking or hiring a carriage for every trip. But now there is to be an electric street railway. The enterprise has been opposed and hindered in every way. Some didn't want the looks of certain streets spoiled by the erection of poles and wires, and others objected to tracks being laid in certain streets because it might injure those thoroughfares as driving courses. But the company has finally got the right of way, and the road is now being built.

The new electric motor on the Willows branch of the Naumkeag Street Railway at Salem was tested July 21, a car being run from Webb street to the Willows and return. The car ran easily. The line to Washington street will be completed this week. The rumor that an injunction had been placed on the running of the electric cars by the Boston & Maine Railroad, on account of the wires passing over the Maine railroad tracks in reach of men on the top of cars, is authoritatively denied.

The new electric railroad at Meriden, Conn., run by the Daft overhead system, has been tried several times and has been very satisfactory. One or two slight "hitches" have been experienced, but these are now remedied and will not be repeated. The line will be formally opened shortly and running on a regular schedule of time.

At a meeting of the Boston aldermen, July 30, a petition from the West End Railway was presented, asking for the right to establish and maintain the electric system of motive power in the operation of its cars, and to erect and maintain poles and wires for the overhead system in some streets, and for leave to establish, maintain and use the conduit system in certain other streets, and to make the necessary underground and surface alterations therefor. The same company petitioned for a location on Harvard bridge and West Chester park, and that a part of the bridge be set apart for the use of street cars. Both petitions were referred to the committee on railroads.

A large party headed by president Whitney and the directors of the West End Railway, joined in experiments with the Thomson-Houston system of electric cars at Crescent Beach and inspected the works of the company at West Lynn, July 30. On the arrival at the beach the electric motor car, which for some weeks past has been running on Atlantic avenue, was found attached to two ordinary street cars. It was learned that the weight of the motor car was 9,500 pounds when empty, and when occupied by 47 passengers was 17,000 pounds; 8½ h. p. being required to remove it 12 miles an hour. The weight of the three cars was 19,500 pounds, and with the 79 passengers, 32,000 pounds. Propelled from an overhead wire, the train moved toward the Atlantic House at a moderate rate of speed, stopping at intervals to test the apparatus for checking motion. By this system the difficulty is avoided of having to adjust the armature bearings at each trip. Another gain is in the use of only one commutator for each motor. There are also self-oiling bearings, the armature turning in an oil cup. In the overhead connection the insulators surpass others in the completeness with which they save dynamic leakage. When the first trip and return had been made with three cars, two trips were taken with the motor car alone, to permit the party to note the speed which could be safely attained. On the first passage over the track, which is 4,870 feet in length, the rate of speed ranged from 12 to a little more than 13½ miles an hour, and on the second trip it reached a speed of upward of 15½ miles. Among other excellencies incidentally discovered during the trip were the mechanical arrangements which prevented the sparking of the track and armature, and the valuable lightning arresters, designed to prevent the burning out, which has been known to occur at Rochester and some other places. After an hour in the dining hall of the Strathmore Hotel, the party, by invitation of the officials of the Thomson-Houston company, visited the works. The last of 61 new open cars will be put into service next week. The Newburyport Car Manufacturing Co. is building 20 box cars for the Beacon street electric line. Colonel Bancroft, the roadmaster of the company, is constructing the tracks on Beacon street, westerly from Harvard street, as fast as possible. The line to Chestnut Hill will in all probability be completed in four or five weeks. The Sprague Electric Railway & Motor Co. has already begun to prepare the equipment for the cars which will run on Beacon street, Brookline. President Whitney expects to have the road in operation by October 1.

The selectmen of Brookline gave a hearing on the 16th ult., upon the petition of the West End Street Railway Co. for leave to erect and use an electric system of motive power in the operation of its cars in the town. President Whitney said that two or three months ago officials of the company visited Brooklyn, N. Y., and were so well satisfied with the working of the overhead conductor system there that they stopped work in Boston on the cable system. President Whitney and other officials then visited Richmond. There they found an overhead wire system in operation, comprising about 12 miles of road in which there were curves such as do not exist in the many miles included in the West End system. The system there had given entire satisfaction, and it was probable that before October next 75 or 100 cars would be running in that city. Alleghany was also visited. There the same system was in operation, and the cars were propelled over grades not exceeded in the vicinity of Boston, excepting Summit avenue on Corey Hill. The company's officers who examined these roads were convinced of the practicability of the motor employed. There was still opportunity for great improvement, Mr. Whitney said, but the use of electricity had reached a stage of development which warrants its adoption in the place of

horses. The company purposes to use a cable in the city and an overhead system in the suburbs. On Beacon street the plan is to suspend the cable carrying the electric current from cross wires attached to gas pipe posts set upon either side of the track about 22 feet apart. The space between the trees where the tracks are located will be grassed over, adding materially to the beauty of the street. If the petition of the company is granted, Mr. Whitney said the system will be in operation early in September, if not on the 1st of that month.

In response to inquiries, Mr. Whitney said the limit of speed on the road would only be determined by the question of safety. He had ridden at the rate of 15 miles an hour or over on the roads which he had examined. It would be possible on Beacon street to make 15, or even 20, miles an hour.

Mr. Dana Estes spoke warmly in favor of granting the petition. There was no opposition expressed in regard to the introduction of the system on Beacon street, but several speakers object to its use on Longwood avenue, which is a narrower thoroughfare. The selectmen took the matter under consideration.

BOSTON, August 16, 1888.

CHICAGO.

Annual Gatherings of the Military Telegraph Corps and Old Time Telegraphers; Address of President Plum; Election of Officers.—Embarrassment of Telephone Service by the City Ordinance of last January.—The Cushman Telephone want a Re-hearing by Judge Blodgett.—The Ordinance Limiting Telephone Charges.—A Chicago Physician Criticises the Telephone Service.—Chicago Electric Club Notes.—The Storm of August 2.—The Sperry Electric Company.—The Western Electric Company to Furnish the Electric Lighting for the Exposition.—Success of the City Lighting Plant.—A New Motor by Mr. Sperry.—The Illinois Phonograph Co.—Suits against Shareholders of the Great Western Telegraph Co.—Electric Light Notes.—New Incorporations.

THE United States military telegraph corps and the Old Time Telegraphers' Association held their annual sessions in Chicago, August 15–16. The two organizations are practically one. The object of the annual reunions is mainly social; but for some time the military corps has been endeavoring to secure from Congress, some recognition of its services during the rebellion. In his annual address the president W. R. Plum, of Chicago, spoke of the important aid which the telegraphers had given the Union cause. Notwithstanding this the service had been unrecognized, he said, and not an operator of the corps had ever received a pension, an acre of land, a bounty, or even thanks. Only the officers who were commissioned to command the corps had been honored. The address contained many extracts from reports in which the zeal and faithful unobtrusive service of the operators were commended by commanders. A resolution of sympathy on the death of the general of the army was ordered sent to Mrs. Sheridan. The following officers were elected :—

President, W. R. Plum, Chicago; vice-president, George C. Maynard, Washington, D. C.; secretary and treasurer, James E. Pettit, Chicago.

The Old Time Telegraphers' Association held its annual session August 16th. The society includes in its membership all those who handled telegraph instruments during the first 25 years of the history of the telegraph. The association has for its object the collection and preservation of all records relating to the early days of the telegraph. The following officers were elected :

President, Charles E. Taylor, Frankfort, Ky.; vice-president, Day K. Smith, Kansas City, Mo.; secretary and treasurer, W. J. Dealy, N. Y.; executive committee, R. J. Hutchinson, N. Y.; S. B. Fairchild, St. Louis; J. M. Turner, New Orleans; Uriah B. Wilson, Denver, and the officers *ex officio*. It was voted to hold the next reunion on the first Wednesday and Thursday of September, 1889.

At the close of the session, the members of the two organizations joined in an excursion on the lake. In the evening a banquet was given at which there was a large attendance. The occasion was of a particularly pleasant character. The members who are full of reminiscences enjoyed the opportunity of comparing notes and living over the days which were passed on the battlefield. The following toasts were responded to :—

"Professor Morse, the inventor of the telegraph. God gave him to us, and after he fulfilled his mission God has taken him away," J. D. Reid, New York. "The Army Telegrapher, first in war, first in peace and last in the hearts of his countrymen," A. H. Bliss, of Chicago. "The Boys," N. L. Ives, of New York. Colonel R. C. Clowry, of Chicago, made a brief speech. The banquet closed with the singing of "Auld Lang Syne."

There is a great deal of fault found at present with the ordinance which prevents the Chicago Telephone Co. from extending its lines. The ordinance was adopted in January last, and provided that the commissioner of public works should issue no more permits to the telephone company until directed by action of the city council. There are now said to be over 210 persons who have made applications for instruments but are unable to secure them on account of this piece of local legislation. Physicians who have recently moved to the city and storekeepers who have recently established their business seem to be the greatest sufferers. They feel that competitors who have telephones have a great advantage over them, and they complain bitterly. The company has not fought the ordinance, because it is said its officers did not desire to increase the business while moving into the new building. Superintendent Wilson said on this subject: "We could soon supply all applicants if the prohibitory order were repealed In the outlying districts it might take some time, but we could put in a thousand instruments in a few months. We have made plans to give Chicago the most perfect telephone service in the world, but we can do nothing more until we can extend our underground system. We are putting in some telephones on private property, but that is all."

Professor J. P. Barrett, city electrician, said he thought the prohibitory order extremely bad policy, and resulted in more harm to the city than to the company. "I have," he said "at times 50 callers a day who make complaints about the order. They cannot see any sense in the order and neither can I. It should be abolished at once."

Assistant corporation counsel Knight, who is the legal adviser of the Cushman Telephone Co., of Chicago, recently said in reference to the adverse decision of Judge Blodgett, "The Cushman people will endeavor to get a re-hearing before Judge Blodgett, and if this is granted and additional evidence is submitted the decision may be reversed, so we can get our instruments and go ahead with the exchange in Chicago. The company is ready to establish exchanges as soon as legal matters can be settled."

The ordinance which reduces the charges of the Chicago Telephone Co. will come before the council again in September. Its franchise may be called in question if a fight ensues. It has been asserted that the Cushman franchise might become valuable as the only one which would permit of the use of wires for telephones in case the Chicago company should be defeated. The Cushman officials declare they would not dispose of their franchise under any circumstances, and the Chicago company officers insist that they would not buy it even as a last resort.

Some comment has been caused by an open letter addressed by Dr. E. M. Hale, a prominent Chicago physician, to the Chicago Telephone Co. It was a stinging criticism of the service. He ridiculed very sarcastically and at considerable length the practice of attributing every fault in the system to induction. He found that the company was guilty of many and weighty sins of omission and commission.

The Chicago Electric Club has voted to discontinue literary meetings until the first session in October. At a recent meeting of the officers and managers the following committee was appointed to consider the question of securing new quarters for the club: S. A. Barton, C. A. Brown, B. E. Sunny, C. D. Shain and H. Ward Leonard.

The present rooms, while pleasant and comfortable, are not as elegant as many members would like to see. The cuisine especially has been the cause of considerable fault finding. At a meeting of this committee, H. Ward Leonard and B. E. Sunny were appointed a sub-committee to visit and report on rooms adjacent to the University Club.

President Barton, of the Electric Club, has brought up the question of organizing an electric exchange similar to the New England Exchange of Boston. The matter has been informally discussed by the officers and managers, and the following committee has been appointed to consider the matter: B. E. Sunny, C. A. Brown, C. D. Shain, J. P. Barrett and F. W. Horne.

The storm of August 2d was unusually severe in Chicago. Lightning struck in eleven places. The stables belonging to the Union Stock Yards and Transit Co. were struck, and a loss of $15,000 was occasioned. The fire alarm system of the town of Lake was rendered useless. Lightning affected the instruments in the telephone and telegraph offices, but beyond frightening the employés did no harm.

Most of the stock of the Sperry Electric Co. has been placed, and an organization has been effected by the election of the following officers: president, Samuel P. Parmly; vice-president, D. P. Perry; secretary, George H. Bliss; treasurer, E. E. Crepin; electrician, E. A. Sperry. The capital stock is $250,000.

The electric motor has recently been employed to excellent advantage for running fans in the sick room, in Chicago. A complete fan outfit run by two cells of storage battery has kept comfortable an apartment in which a Chicago capitalist has been confined by a broken leg.

The Western Electric Co. will furnish 200 arc lights for illuminating the Chicago exposition building this fall. A considerable number of incandescent lamps will be installed, and current will be supplied for several Baxter motors.

A Chicago amateur detective recently made as he thought an important discovery which threw light on a tragedy. Mr. and Mrs. Heesch were found dead in their home. The man had beyond doubt committed suicide, but the woman's death formed a mystery. The amateur detective found an electric battery in the house, and formed the theory that the husband while assisting his

wife to take an electric shock had administered a fatal charge, and in his despair had taken his own life. An electrician who was consulted, upset the theory by saying that two dollar batteries are not sufficiently powerful, ordinarily, to cause death.

It is asserted that the city electric plant besides affording improved illumination, will prove an economical venture for the municipality. Figures show that the cost of maintaining each electric light will be $15 per year, while the cost for the gas lamps has ranged from $20 to $30.

Elmer A. Sperry has invented a double induction motor, for which great excellence is claimed. The inventor asserts that its construction is such that its efficiency is high, and that the unsatisfactory working which usually characterizes small motors is entirely overcome. The motor can be operated from a battery or from an arc or incandescent circuit.

The Illinois Phonograph Co. has been incorporated, with headquarters in Chicago. The capital stock is $1,250,000. The incorporators are Frank A. Wunder, William L. Abbott, and Henry P. Barton. Harmon Spruance, formerly of New York city, has purchased the right to rent instruments in Illinois, and is at the head of the movement in Chicago.

United States senator Charles B. Farwell, of Chicago, has been sued for 1,500 by Elias R. Bowen, receiver of the Great Western Telegraph Co. Senator Farwell was one of the original subscribers to the capital stock of the company, and there is $1,500 yet due and unpaid on his stock. Mr. Farwell is only one of several hundred stockholders who are being proceeded against for the benefit of the company's creditors.

The capital stock of the Consumers' Electric Light Co., of Chicago, has been increased from $100,000 to $200,000.

The Normal Electric Light Co., of Normal, Ill., has been incorporated with $5,000 capital stock. The incorporators are M. T. Burrell, C. L. Gilt, H. C. De Motte, O. Seibert, and Charles De Garmo.

An electric light plant is to be installed in the Chicago North Side Waterworks, for the illumination of the shore inlet and the water works.

The South Side Electric Light & Power Co. has been incorporated with $50,000 capital stock. Those interested in the company are H. V. Harris, James Hood and Frank Butterworth.

The Electric Date and Time Stamp Co., of East St. Louis, has been incorporated. The capital stock is $1,000,000, and the incorporators are William H. Stevenson, James B. Johnson, J. M. Thompson and Hamilton Doughorday.

The Citizens' Electric Light Co., of Collinsville, Ill., has been incorporated; capital stock $100,000; incorporators, S. W. Baird, A. P. Baird and M. T. Baird.

The electric lighting plant at the stock yards has been completed. The cost was $12,000. Considerable of the stock received at the yards is unloaded at night, and the danger in unloading is great. There is also a good deal of switching and shipping done. No part of the yards is now in darkness. There are 70 lights supplied by two dynamos. Fifty-one are in use at present. The lights are brilliant, steady and economical. They extend from Winter street to Ashland avenue along 40th street. There is a cluster of lights upon a tower in that part of the yards where most of the work is done. The tower is 120 feet from the ground, and may be seen at a great distance.

CHICAGO, August 21, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, *11 Wall street, New York city.*

WELDING RAILS BY ELECTRICITY.

[97.]—I find it necessary to respond again to Mr. Otis K. Stuart's attack on my method of welding rails by electricity, which he renews in your August number.

It appears that Mr. Stuart is not yet entirely satisfied that he is in the wrong, and after very conveniently waiving all further discussion of the points first brought up by him, he now grasps at one or two remaining straws in a vain attempt to prove that the welded joints of the "continuous" rail sections cannot be retempered. He then proceeds, under the flattering assumption that I know nothing about welding, to discourse to the reader at length upon the results of his own experience with welding currents, and endeavors to explain the *modus operandi*, according to his conception of what takes place, in a direction that is entirely foreign to the questions at issue between us.

Mr. Stuart starts out by stating that his previous letter was *not* a criticism of my method of welding and laying railway tracks, but was prompted by the general statement or notice originally published by you. Yet, a little further on, he admits that he was acquainted with my patent when he wrote his first letter, and confesses that he was *then* and is still unable to find therein any method of restoring the temper. It is very easy not to find a thing when one doesn't wish to find it, but nevertheless the method of re-hardening or re-tempering the welded joints is operatively described in a manner sufficiently clear to enable anyone skilled in the art of electric welding to practice it, as may be readily seen by referring to the patent itself, No. 370,282.

Aside from all this, however, I am prepared to maintain, notwithstanding anything Mr. Stuart has said to the contrary, that with the proper arrangement of welding clamps and apparatus, and re-hardening and tempering means, such as I propose to employ, the welded rail joints can be restored to their normal degree of hardness *without leaving an annealed portion on either side*, and it appears to me to be futile for Mr. Stuart to indulge in prophesies of failure until after he has something more tangible to base them upon than theories derived from the state of his present knowledge.

Mr. Stuart, however, not satisfied with denying the practicability of what I still persist in terming "my method of electrically welding and tempering," goes further than this, and, presumably referring to claim 2 of my patent, in which is set forth the feature of gradually increasing the current strength, states positively that no greater piece of electrical nonsense has ever been written. We shall see. It is a fact well known to every blacksmith or tool maker that good steel will not bear a white heat in the open air without being "burned," and that even at a bright red heat it will crumble under the hammer. Is not Mr. Stuart's position, therefore, utterly absurd when he states, in this connection, that in dozens of foundries in this country steel is melted and poured into moulds, with no gradual increase of the current to prevent burning?" Does Mr. Stuart mean to imply that because steel can be cast without destroying its tempering properties, that he can therefore subject a bar of steel, clamped in his welding machine, to any degree of heat with impunity, and without burning it or injuring its tempering qualities?

Mr. Stuart further states that he has frequently welded steel without injuring its tempering qualities, by gradually *reducing* the flow of current. What does this prove in this connection? Nothing. Anyone familiar with electric welding knows that a weld can be effected with a constantly diminishing current strength, if the precaution is taken to have the ends of the pieces in good, square contact at the beginning of the operation. In this case the resistance opposed by the joint is comparatively small at first, permitting a large initial flow of current that is automatically reduced as the metal becomes heated, and increases in resistance by virtue of this heat. This method of operation is not generally followed in practice, as Mr. Stuart fully knows, for in order to localize the heat more thoroughly, it is usually necessary to reduce the cross-section at the ends of the pieces to be joined, this latter method also producing a more perfect joint, by reason of the more intimate union of the metals that occurs when the pieces are forced together. In this method of operation the resistance of the joint is usually *greatest at the commencement of the welding operation*, and *diminishes* as the metals are forced together and the joint approximates its full diameter. It will be seen therefore that even without the aid of exterior regulation to assist this action, the current in this case, with a constant potential in the welding circuit, *is of necessity a gradually increasing one*, and I have no hesitation whatever in saying that most of the work done by the machines of the Thomson Electric Welding Co., whether by Mr. Stuart or anyone else, *is a direct infringement of the second claim of my patent*, quoted in my previous letter in the July number of the ELECTRICAL ENGINEER. Is it any wonder that Mr. Stuart is so anxious to have the public believe his assertion, "that a greater piece of electrical nonsense has never been written than the statement made in claim 2?"

One more point, and I am through. Mr. Stuart evidently confuses a gradual heating effect with a gradual increase of current strength. These are entirely distinct, and in one sense absolutely independent of each other. It is the gradual increase of *current* that forms the subject of the claims under notice, and *not* the gradual increase of the heating effect. This latter is mainly a function of, and depends upon, the heat conductivity of the metals, and it is because of the comparative slowness of this action and the consequent liability of overheating that portion of the joint first acted upon by the current, that the necessity arises for "gradually increasing" the current strength. It will be readily seen that in the welding of large pieces, such as steel rails, if the full welding current is suddenly passed between the tapered ends of the rails there is decided danger of abruptly raising these abutting portions to a white or "burning" heat before the fusing action of the current and the heat convection combined has appreciably affected or heated to redness the ends of the rails proper. The automatic variation in the resistance of the joint, before referred to, cannot always be *alone* relied upon to permit of the desired flow of current, and in the welding of steel, or in fact *any* metal the structure of which is such as to become injured by overheating, I employ a suitable reaction coil or other regulat-

ing device by means of which the initial current can be adjusted to suit the *area of contact* at the ends of the pieces about to be united, and by which the current can be gradually increased as the ends of the metals unite and the increasing cross-section at the joint demands a heavier current.

Of course, Mr. Stuart is at liberty to weld as often as he pleases by *reducing* the current, and as $H = C^2 \times R \times T$, he can within certain limits, go a step further, and devote all the time he likes to the operation by using a still smaller current. For my part, I find that *increasing* the current strength, as described and claimed for the first time in my before mentioned patent, fills the bill to perfection, and at the same time permits of more perfect, rapid and economical work, not only in the case of steel, but in other metals.

Thus far I have been unable to see a single point in my system that has been met or weakened by anything Mr. Stuart has said, and if, as requested in my previous letter, Mr. Stuart will wait until he sees a practical railway line having continuous rail sections in successful operation, he will I trust, like a good many other doubting Thomases who flourished before him, eventually see things in their proper light. ELIAS E. RIES.

430 S. Broadway, Baltimore, Md.

GLASS HOUSES AND STONE THROWING.

[98.]—In reading your remarks in your last number about a contemporary who had lectured the fraternity of technical journals for cribbing from its columns without acknowledgment, and noting particularly your quotation against him of the old adage "People who live in glass houses should not throw stones," in an expanded and odious metrical paraphrase, due, I suppose, to some scribbler emulous of the Great Tupper's fame; it occurred to me that you must have failed to read with due attentiveness Mr. Rice's monthly magazine (issued under the sometime-honored title, *The North American Review*) for March last. In that number, among the writers relegated to fine print on the back pages, Mr. Walter Gregory very cleverly and successfully demonstrates the absurdity of the adage about stone throwing from glass houses. He says the occupants of glass houses "are the only ones who may" throw stones, and his ground is that it is only those addicted to particular sins and vices who can speak understandingly about such sins and vices; as to the good and virtuous, "their very immunity and perfection disqualifies them." Mr. Gregory further says, "The new doctrine is the one to which we must come. * * * When it prevails we shall all be wiser and happier than in these days when we are 'censors of such vices as we are not tempted to commit, and satirists of such virtues as we are not allured to imitate.'"

May not your esteemed contemporary have simply put in practice this new and better teaching? F. J. R. C.

LITERATURE.

REVIEWS.

Betrieb der Galvanoplastick mit Dynamo-Electrischen Maschinen zu Zwecken der graphischen Künste. Von OTTOMAR VOLKMER. Wien, Pest, Leipzig. A. Hartleben's Verlag.

THIS little volume of the *Chemisch-technische Bibliothek* presents in a clear and comprehensive way the principles and the essential details of various forms of electroplating and electrotyping. The book is a model of definiteness and conciseness. The amount of information is unexpectedly great. Systematic arrangement and the omission of unessentials contribute largely to the author's success. His descriptions and conclusions are for the most part based upon the instruments and experiments in the royal "Militär-geographische Institut" and the "Hof-und Staatsdruckerei" at Vienna, and include many recent and interesting processes of reproduction of figures by the electric current. The statistics of the current and amount of metal deposited, collected and collated by the author, are comprehensive and very useful for reference. It is a pleasure to find a German scientific writer who takes some pains with his style of presentation. Herr Volkmer, with some other recent German scientific authors, apparently respects the time and patience of his readers and recognizes the duty of an author to be perspicuous.

The discussion, in the first chapter, of the dynamos used for plating is wisely confined to the Gramme, Schuckert and Krötlinger machines, "because in Germany and Austria these systems have enjoyed greater favor." By reason of this concentration it is possible to give full and accurate data. The author avails himself of this, and gives a thoroughly satisfactory account of the construction of the machines, the power necessary to run them, and the work that can be got from them. The few pages he devotes to the statement of the fundamental principles of the dynamo and the description of ammeter, voltmeter and gas engine are quite admissible, as being not out of place in a popular development of the subject.

Chapter Two, which sets forth the laws of electrolysis, contains, besides the laws of Faraday, the results of several experiments. The most important are those of Baron Hübl (of the Militär-geographische Institut), which determine the physical peculiarities of electrically deposited copper and the conditions for the production of a good plate. The general laws of Smee and others on the relations between the strength of current and the nature of the deposited copper, are well supplemented by the definite results of Hübl. The table showing the relation between the composition of the bath and the maximum useful current per sq. dm., is particularly good. Hübl's determinations of the absolute rigidity, the limits of elasticity and hardness of the metal under different conditions, are of significance and importance to the specialist. The sections on the arrangement of the bath and plates are interesting, as showing the method employed at Vienna. The cautions of the last part of the chapter are worthy of some attention by those not already informed.

In the fourth chapter is found the main substance of the book. Brief but accurate accounts are given of the preparation of the ordinary plate, and that faced with steel, nickel or brass, as well as of the most important methods of photo-mechanical reproduction. The author, without sacrificing technical accuracy, has succeeded in putting his work in popular form. Of the eighteen processes described it will be possible to mention only a few of the most interesting. Not least important is the steel facing of a copper plate. Four or five minutes suffice to deposit a layer of steel, which will give from 6,000 to 12,000 impressions without renewal; after which, renewal is quite as easy as the original process. To this process and to the heliogravüre, considerable space is rightly devoted. The novel feature of the chapter is the description of electrotyping flowers and insects from nature.

The author, through his position under the government has had excellent opportunities for observation, and it is a satisfaction to find him so definite in his statements. The reader is left in no doubt as to the composition of the solutions, or the amount of current necessary for a given result. He is even admitted to a view of the machinery. It is just in this particular of definiteness that the value to the specialist of this part of the book lies.

The plan of the book is adhered to in the last chapter—on chemicals. The main facts regarding the substances employed are briefly stated for general information. Yet it is not alone the general reader that can profit by the succinct record; though even with the tables of density in the appendix, its use as a reference book is necessarily very limited. On the whole, this exposition of the processes (as they exist in Germany) of electro-metallurgy for purposes of graphic art is quite timely. That many of the methods are already well known is no reason why they should not be published in logically complete form, and an interesting, not to say valuable, description given to the world.

Principles of Dynamo-Electric Machines. By CARL HERING. New York: W. J. Johnston, 1888.

MANY readers of THE ELECTRICIAN AND ELECTRICAL ENGINEER will remember the admirable serial article on the construction of dynamos, by Carl Hering, which ran through the fifth and sixth volumes of this journal, and will recall with pleasure his original method of treating the subject, as well as the simplicity and clearness of his style. The republication of this serial in the shape of a handy little volume, with such revisions and additions as the author has thought to be desirable, will be sure to meet with the approbation of those who were fortunate enough to be familiar with it in its original form, while to many who were not so favored it will come as a most acceptable manual.

Mr. Hering's practical familiarity with the various types of modern dynamos has enabled him to treat of the details of their construction in a manner which few writers have attempted, and he has consistently confined himself to that practical treatment of the subject which it was his stated intention to pursue. The design of the book is to give in a concise and simple form the information most required by those using, building or repairing dynamos, and it is little to say that this object has been successfully accomplished.

The general plan of the author has been to take as a basis for his reasoning, or as models, those modern dynamos which have proved in practice to be the most efficient converters of energy, and from their actual dimensions deduce the best proportions for the various elements in dynamo construction, and the theoretical reasons why such designs must be, on general principles, the most effective. His method is strictly analytical and the practical illustrations which are always given are followed in a logical manner by all essential explanations of the underlying theory.

For the benefit of such readers as may not have the necessary knowledge of the fundamental laws of electricity, and of the units and terms commonly employed in dealing with electrical phenomena, the first chapter has been devoted to their explanation. Potential, current and resistance, and their relation to force and work, are clearly and ably defined, as well as most of the electrical phenomena with which the book is concerned. The reference in this chapter to the earth as a reservoir of electricity of infinite quantity, is not scientifically accurate, however, and seems to be unnecessary as well as misleading. In discussing the

fundamental principles of dynamos and motors in the next chapter, it is shown that complicated theories as to their action are unnecessary, and in illustration, some simple and instructive experiments are described. This is followed by a clear and comprehensive explanation of the theory of magnetism and electromagnetic induction, which cannot fail later on to aid the student in understanding the principles upon which the action of dynamos depends. The laws governing the generation of electromotive force in such machines are next considered, and this force, which is the fundamental element with which we have to deal, is shown to be dependent on the length and velocity of the moving conductor and on the intensity of the magnetic field traversed by it, in a way that can be readily comprehended by those having but little familiarity with the subject.

After this preliminary and very useful explanation of principles, the author passes directly to the practical construction of dynamos. The various types of armatures are described in detail, and their differences and advantages for particular work pointed out. Practical methods of designing and winding armatures to accomplish predetermined results, are explained with sufficient fulness to enable any ordinarily intelligent person to apply them successfully. The various forms given to field magnet frames are carefully considered and their effectiveness criticised, and rules for winding such frames with series or shunt coils, are laid down in great detail. In all of this portion of the work the author's actual experience in manufacturing machines is made apparent. No details are thought too insignificant to receive attention, and it is this completeness that will make the volume particularly valuable to the dynamo builder. Methods of regulating dynamos and of testing machines during and after construction are fully set forth in the concluding chapters, and indeed it may be said that nothing relating to a dynamo-electric machine from its conception to its completion has been omitted.

The volume is concluded with much valuable matter in the form of five appendices. The first of these deserves more than passing mention, and will repay a careful perusal by all who are interested in well proportioned dynamos. It is nothing more than a skillful tabulation of the various mechanical dimensions and electrical quantities of the seven dynamos tested in 1884 by the Franklin Institute committee, and it shows in a convenient manner how the various mechanical proportions of these machines have affected their electrical output. The conclusions which may be drawn from these comparisons are admirably discussed in the accompanying text. The so-called dead wire in Gramme armatures, and certain explorations of the magnetic fields surrounding well-known types of dynamos receive attention in two other appendices, while the fourth describes several methods of winding drum armatures. The fifth appendix is Mr. Hering's well-known table of equivalents of units of measurement, with several useful additions.

Electrical artisans and students, and those engaged in manufacturing and handling dynamos, will find this volume to meet an acknowledged want, and to such it may be commended with confidence.

RECENT PUBLICATIONS.

An Empirical Rule for Constructing Telephone Circuits. By William W. Jacques. From the Proceedings of the American Academy of Arts and Sciences. New series, vol. xxiii. Paper, 8vo., 13 pp.

A Practical Method of Calculating and Designing Dynamos and Motors. By Francis B. Crocker. A Paper read before the New York Electrical Society, March 28, 1888. New York. Published by the Society. Paper, small 4to., 15 pp. Illustrated.

On Some Possible Methods for the Preparation of Gramophone and Telephone Records. By Professor Edwin J. Houston. Read before the American Philosophical Society, April 20, 1888. Paper, 8vo. 4 pp.

CATALOGUES AND PAMPHLETS RECEIVED.

The "C. & C." Electric Motor Co. continue to issue tasteful and elegantly illustrated circulars setting forth successful applications of their motors. Their last pamphlet exhibits, along with several other uses, the adaptation of their motor to the propulsion of small boats or launches. An application which should prove very acceptable to people who have had to sit near a hot and hissing steam boiler in a small pleasure boat.

The New Haven Clock Co. some years ago, in reaching out for new fields, dashed in among the manufacturers of electrical apparatus, and have now become prominent competitors of old established electrical manufacturing concerns. Their recent catalogue represents a very full line of electrical apparatus, being specially full in telegraphic and other signaling machinery and supplies.

I. W. Colburn & Co.'s (Fitchburg, Mass.) price list and hand-book of dynamos and electric lighting apparatus and supplies, is a very dainty little book—small enough for a watch-pocket—and contains much useful and interesting matter. As was the case with Mr. Samuel Weller, our "wision is limited," and we have not been able to get the full benefit of the pages printed in microscopic type.

Mr. M. Richards Muckle, Jr., of Philadelphia, inventor of an underground conduit system for electric wires, has done well to include in his pamphlet describing his system the full text and drawings of his several United States patents thereon. Circulars of this character are too frequently—almost always—devoid of detailed information of the devices or schemes set forth, and are chiefly filled with more or less extravagant claims of a general kind, to supreme excellence. Mr. Muckle is of the firm of M. R. Muckle, Jr. & Co., engineers, Philadelphia.

The Daft Electric Light Co., now removed and established in its commodious factory at Marion, N. J., has isssued a handsome cloth bound quarto of 38 pages under the title—Distributory Electrical Power Plants, Daft System. In addition to illustrated descriptions of the Daft dynamos and motors, the book contains a considerable number of reports by people who have used the Daft motors. The descriptive portion ends with the following frank expression:—"It should not be overlooked that the foregoing description of Daft electrical power plants only applies to their status at the time of writing, and that a very brief interval may render it comparatively obsolete." All others engaged in electrical motor enterprises might truthfully say the same.

The Gibson Electric Co. recently issued a pamphlet circular setting forth the merits of the Gibson storage battery. Mr. Gibson, like many other inventors who have taken up the accumulator problem, has devoted his attention chiefly to devising methods of construction that would prevent rapid distortion and disintegration of the battery plates, and very remarkable results in that direction are claimed for his accumulators in the pamphlet under notice. The office of the company is at 775 Greenwich street, New York city.

NEWS AND NOTES.

DECISIONS IN PATENT SUITS.

THE THOMSON-HOUSTON REGULATOR PATENT SUSTAINED.

Circuit Court of the United States, District of Massachusetts.

IN EQUITY.

THOMSON-HOUSTON ELECTRIC CO., v. CITIZENS' ELECTRIC LIGHT CO., ET AL.

OPINION OF THE COURT.

[August 14, 1888.]

COLT, *J.* This suit is brought for the infringement of letters patent No. 238,315, granted Elihu Thomson and Edwin J. Houston, March 1, 1881, for improvements in current regulators for dynamo-electric machines. The specification says:—

"The object of our invention is to provide improved means for controlling automatically the strength of an electric current flowing over a circuit composed of a dynamo-electric machine and one or more electric lamps, or other appliances, through which the current passes, and to obtain said control without the introduction of resistances as such, and without varying the speed or field of the dynamo-electric machine, and at the same time, if desired, to utilize the reaction principle for the magnetization of said dynamo-electric machine, or in other words, to cause the current generated to pass through the field-magnet coils. We accomplish these results at the same time that the power expended to drive the dynamo-electric machine varies directly in accordance with the changed resistance of its circuit, being less as the resistance is less, and greater as the resistance is greater. * * * In the improved system of operation provided by our present invention, we possess the ability to cut out lamp after lamp from circuit, and yet maintain a uniform current strength in the remaining lamps and economy of motive power proportional to the diminished resistance, while the normal light-giving power of each lamp not cut out is maintained, and an absence of heating or necessity for any other adjustments than those at the commutator of the machine obviated. These adjustments are preferably made automatic, for we find that with the commutator used by us, as herein specified, a proper adjustment of the commutator being effected when a certain resistance is in circuit, a similar adjustment will, when the resistance is changed, give the same current. In our system we have employed a dynamo-electric machine in which the commutator is constructed of three insulated segments of a ring connected to three armature-coils. The collecting brushes applied to said commutator are supported so as to be movable around the commutator without changing the relative positions of the two collectors. This movement of the collecting brushes is well known in the art. * * * We find in practice, moreover, that we obtain with this automatic regulation of the current strength an independence of speed variations in the machine, it being only necessary to so adjust the speed of running that when the speed is at its lowest the machine shall yet be sufficient in power to maintain the number of lights placed in its circuit. We are therefore able to operate successfully under conditions of motive power variations that have hitherto been recognized as fatal to steadiness of light obtained.

"In United States Patent No. 223,659, January 20, 1880, before referred to, we have described a means of automatically adjusting the commutator collectors of dynamo-electric machines, which method is adaptable to the present case of current regulation. * * * Our present method of operating, therefore, so far as it relates to automatic regulation, is based upon the same principles of operation as our previous invention; and it consists in an improved construction and mode of use of the apparatus employed in Patent No. 223,659.

"We claim:—

"(1) In a current-regulator for a dynamo-electric machine, the combination of a device responding to changes in the main or generated current, a shifting commutator for said machine, and mechanism controlled by said responsive device to shift the commutator to those positions where the current, taken up by said commutator, shall be constant.

"(2) In a current-regulator for a dynamo-electric machine, an electro-magnetic device acted upon by variations in the main or generated current, an adjustable or shifting commutator for the

machine, and mechanism controlled by said electro-magnetic device to adjust the commutator to those positions where the main or generated current taken up by said commutator shall be constant."

The main defense in this case is that the prior Patent No. 223,659, issued to these complainants, is an anticipation of the patent in suit. Upon careful examination of the two patents in connection with the testimony of experts and the able arguments of counsel, I cannot agree with the position taken by the defendants. The object of the two patents, as disclosed by their titles, is different; the patent in suit is for a current regulator for dynamo machines, the earlier patent is for an automatic adjuster for commutator brushes on magneto-electric machines. Current regulation, or "to provide improved means for controlling automatically the strength of the electric current," is the object of the patent in suit, while the object of the prior patent was the construction of an automatic adjuster for commutator brushes, "whereby an automatic adaptation to variations of circuit resistance is secured, and the burning and destructive effects of false adjustments obviated." The design of the present patent is to adjust the commutator to those positions which shall keep the current constant; the design of the prior patent was to adjust the commutator so as to keep the current at its maximum value, or in other words, to adjust the brushes so that their contacts with the commutator segments should be at the neutral points, by which means the difficulty from sparking would be reduced to a minimum. It is true that the means employed in both patents to accomplish these different results bear a close relation to each other. The patentees declare that the earlier method described is adaptable to the present case of current regulation, but they also say that their present method consists in an improved construction and mode of use of the apparatus employed in the prior patent. To construct an automatic adjuster which shall avoid sparking or leakage by bringing the brushes in contact with the commutator segments at the neutral line, or the points of the maximum difference of potential between the segments, and, therefore, of maximum current, may be an important invention, but it is certainly quite a different invention to adjust the brushes of the commutator to positions which shall keep the current constant, independently of the question whether the brushes touch the segments at the neutral points, or whether sparking is avoided.

It is said that the present invention is shown in figures 1 or 2 of the earlier patent. The testimony of defendants' experts seems to find the invention described in figure 1, while the learned senior counsel for defendants appears to reject this contention and turns to figure 2 as an anticipation of the patent in suit. I do not find in figure 2 of the earlier patent the combination of mechanism which forms the subject-matter of the claims of the patent now under consideration. I do not find that which constitutes the important thing in the present invention, namely, the responsive device responding to changes in the main or generated current. In respect to figure 1, the most that can be said is that it imperfectly describes that which was perfected in the subsequent patent now in controversy. It seems to me in other words that the language of the specification is strictly accurate where it declares that the present invention "consists in an improved construction and mode of use of the apparatus employed in Patent No. 223,659."

Upon the subject of infringement I have no doubt. The question is not as to the form of dynamo the defendants may use, or whether their machine may be adjusted by hand to avoid sparking, but the question is whether they use the complainant's invention by the employment of substantially the same means to accomplish the same result, namely, the regulation of the current by means of a device responding to changes in the main or generated current, and this the complainants have shown.

Let a decree be entered as prayed for in the bill.

Decree for complainants.

THE GAULARD AND GIBBS' PATENT. THE WESTINGHOUSE SUIT AGAINST THE SUN ELECTRIC CO. DISMISSED.

Circuit Court of the United States, District of Massachusetts.

IN EQUITY.

WESTINGHOUSE ELECTRIC CO. *v.* SUN ELECTRIC CO. ET AL.

OPINION OF THE COURT.

[August 7, 1888.]

COLT, *J.* This suit is brought to enjoin the defendants from infringing letters-patent No. 351,589, granted October 26, 1886, to George Westinghouse, Jr., assignee of Lucien Gaulard and John D. Gibbs, for improvements in methods and apparatus for the distribution and conversion of electric energy.

The case has been thoroughly and ably presented on both sides. The patent relates to that branch of the art of electric lighting known as the incandescent. The specification states that the "invention relates to the distribution of electrical energy for industrial purposes; and it consists in an improved art or method and an organization of apparatus, whereby the same is carried into effect, by means of which we are enabled to transmit from a central or supply station, through a main conductor, a primary electric current of comparatively small quantity but of high potential, and at a point or points more or less distant, where the said electric energy is to be utilized, to transfer the energy residing in such primary current of high potential into one or more secondary currents of lower potential, but of greater quantity. * * * At a point where the electric current is to be utilized for any suitable purpose—as, for instance, in one or more incandescent electric lamps—we place one or more secondary generators or converters, as shown at C in figure 1. The general principle of our secondary generator is analogous to that of the well-known inductorium or induction coil, with this exception, that, while the induction coil has heretofore usually been employed to transfer electric energy from currents of low potential and great quantity into currents of high potential and small quantity, the function of the secondary generator or converter, as applied in our invention, is precisely the reverse of this, namely, to transfer electric energy from currents of high potential to currents of low potential and increased quantity. We have constructed converters for effecting this result in a variety of forms, all of which involve the same principle. * * * The most important and characteristic feature of our invention is that which renders it possible to make use of alternating and equal positive and negative currents of moderate quantity, but of very high potential in the primary or main line circuit, and to convert these into secondary or induced currents of much greater quantity but of correspondingly lower potential at the place of consumption, which secondary circuits are employed to do the required work. * * * Any required number of converters of the general construction described may have their primary circuits united with or included in the conductors leading from the primary generator. The manner of connecting such converters whether in series, multiple arc, multiple series, or otherwise, will be understood by those skilled in the art to which our invention relates without the necessity of further explanation." The specification then says that one arrangement is indicated in figure 3 of the drawings which shows an arrangement of converters in series. Then follows this disclaimer: "We do not herein claim the connection of the converters in the line in any other arrangement than we have illustrated in the drawings. Figure 3 of the drawings shows an arrangement of converters in series. The defendants connect their converters in what is known as the multiple arc system, which is quite different in construction and mode of operation from the series system.

There are five claims in the patent, the first being for the art or method, and the remaining four claims for the apparatus.

The first question which arises relates to the proper interpretation of the patent in view of the disclaimer. Undoubtedly, as originally drawn, the patent was intended to cover all forms of converters which transferred electric energy from currents of high potential to currents of low potential and increased quantity, whether connected in series, as indicated in figure 3 of the drawings, or in multiple arc, or otherwise. The patent office refused to grant so broad a patent and instructed the applicants that, in order to avoid an interference, they must confine the arrangement of converters to the series system, that being the arrangement shown in the article in *Engineering*, of March 2, 1883, which the applicants declared contained a description of their invention. Thereupon the disclaimer was inserted. An examination of the file wrapper and contents discloses that the patent office believed this patent should be limited to the arrangement of converters in series, and that this was supposed to have been effected by the disclaimer, otherwise an interference would have been declared. The patentees avoided such interference by inserting the disclaimer, and it is too late now to say that the disclaimer means in effect nothing. If we construe the patent to cover broadly a dynamo producing alternate currents of high potential with a single reducing converter, then the disclaimer is meaningless, because such construction would embrace converters connected in multiple arc or otherwise.

The patent states that the invention is for a system of electric distribution; the true scope, therefore, of the invention is not confined to one converter, but to several converters arranged in a system, and, when the patentees disclaim all systems but the series, they should be held to it.

As we have said Gaulard and Gibbs declare that the invention covered by the patent in suit is found in the article in *Engineering* of March 2, 1883. The defendants deny that the article describes converters which transform the current from high potential to low. Whoever may be right, it appears quite certain that the high potential of the primary, and the low potential of the secondary, or the long thin primary wire, and the short thick secondary wire, which become so important in the patent under consideration are not specifically described or shown with clearness in the article in question. The system described in the article was a general one, and was intended to meet the conditions laid down in the English Electric Lighting Act, which provided that the "undertakers" shall not prescribe to householders and others, to whom they supply the current, the use of any particular kind or form of lamp. The Gaulard and Gibbs invention has a two-fold object, says the article; "firstly, it aims at rendering

it practicable for undertakers to supply current at the most economical potential permitted by the terms of their provisional orders; and, secondly, it is intended to make the user independent of the producer, and to enable him to apply the current he receives to any purpose he may please, such as arc lighting, incandescence lighting, the generation of power or of heat." If the article does show a converter which transforms electric energy from high potential to low, it is evident that Gaulard and Gibbs did not at this time regard this as a great discovery, or it would have been more clearly indicated. Undoubtedly, the article was intended to outline a general system to supply to customers currents of high or low potential as might be desired by means of converters connected in series based upon the principle of the Rhumkorff coil, but that this was to be accomplished by means of a primary current of high potential, and secondary currents of low, is not apparent.

Further, if the reducing converter, now made so important, was discoverd by Gaulard and Gibbs, in March, 1883, and constituted such a great invention, why did it not form the subject-matter of their subsequent American patent of April 29, 1884, and British patent of September 13, 1882?

These things go to prove that the prominence given to the reducing converter in the patent in suit was based upon something else than the article in *Engineering*. I am led to think that it was based upon the fact that, between the date of the article and the date of the patent in suit, other inventions had come to light, and that it was these improvements which induced Gaulard and Gibbs to set up the claim they make in their last patent.

In the patent granted to E. Thomson, July 14, 1885, the converters are arranged in series. The object of the invention was to provide a safety switch for the converters, but we there find described the primary or main current of high potential and the secondary current of low potential. The specification says, "The secondary coil is wound with such coarse wire, and the lamps used therewith are of such low volt potential as not in itself to produce dangerous discharges or shocks." Thomson seems to take it as a matter of course, in view of the prior state of the art, that there was no invention in reduction from high potential to low through a converter.

But the most important improvement was made by Zipernowski and Déri in their English patent, of March, 1885. This patent describes minutely a system of distribution by induction through potential reducing converters combined in multiple arc, and it includes an alternating current dynamo generating a current of high potential.

We see then that the state of the art in 1882, when the article in *Engineering* was written, and in 1886, when the patent in suit was issued, was quite different. It became very important, therefore, for Gaulard and Gibbs to obtain a patent for a single reducing converter, however it might be combined with others in a system. I think the importance given to this point in the patent an effort to expand the real invention of Gaulard and Gibbs as contained in the article in *Engineering*, and that the patent office intended and did in effect limit the patentees to all they were fairly entitled to, namely, the arrangement of their converters in series in a system of electric distribution.

But assuming that our interpretation of the effect of the disclaimer is wrong, and that Gaulard and Gibbs are entitled under their patent to claim the exclusive right to a converter which transfers energy from high potential to low in combination with a dynamo producing alternating currents, can so broad a claim be sustained in view of the prior state of the art?

To uphold this position, of course, Gaulard and Gibbs have to go back to the article in *Engineering* of March 2, 1883, as the date of their invention, because this form of converter in combination with an alternating dynamo is clearly shown, as has been observed in the Thomson, Zipernowski and Déri patents of 1885. But, admitting that the date of the invention was March 2, 1883, I have much doubt whether Gaulard and Gibbs could obtain a lawful patent for so broad a claim. The counsel for the plaintiffs in his closing argument admits that the induction coil or inductorium or converter, in its general sense, as a device used for taking off from the line at different points, a portion of the electric energy whether of the same or higher or lower potential, was well known. The article in *Engineering* states that the secondary generator or converter was based upon the same principle as the Rhumkorff coil. In the English patent granted to Paul Jablochkoff, November 9, 1877, we find described a system for producing and dividing electric lights, which consisted in carrying a main alternating current round an unbroken circuit and transferring its energy by means of induction coils to consumption circuits at the points where it was to be used. The converters are placed in series with one or more lamps in the secondary of each converter. But it is said that Jablochkoff contemplated a conversion from low to high potential, the reverse of Gaulard and Gibbs. At the same time, it was well known that the converter would transfer energy from high to low, or low to high, as the primary wire was longer or shorter. Was it invention for Gaulard and Gibbs simply to reverse the coils and transfer the energy from high to low?

In the English provisional specification of Edwards and Normandy, November 13, 1878, the inventors propose to use either interrupted or alternating currents with a converter near every place where the light is to be produced. The specification says, "At or near every point where it is required that a light shall be produced, we arrange a coil (or series of coils) of insulated metallic wire or ribbon (preferably surrounding a bar or wires of soft iron) through which coil or coils the current from the principal wire first described can be passed when desired, or cut off by means of a key or lever. Round or adjacent to each coil of insulated wire described, we form one or more secondary coils, of insulated, metallic wire or ribbon, arranged so that the passage of the rapidly intermittent current of electricity, as described, through the primary coil or coils generates a corresponding amount of electricity in each of the secondary coils. * * * In order to facilitate the production of the induced electricity, *and to diminish its intensity and increase its quantity*, we prefer making the coil or coils in which the electricity is induced of a number of insulated wires or ribbons made up into a bundle or rope, the ends of the wires or ribbons at each end of the bundle or rope being in metallic contact with each other, which united ends are then joined to the conductor, conveying the induced electricity." Here is found distinctly stated the principle of a reduction from high potential in the primary to low potential and increased quantity in the secondary, which Gaulard and Gibbs assert is their great discovery.

The patent to J. B. Fuller, November 26, 1878, is for an improvement in induction apparatus for lighting by electricity. This invention embraces converters arranged in series like those of the patent in suit to be operated upon by an alternating current. It is not stated whether the potential is to be raised or lowered in the converters, but the drawings appear to indicate that it was to be raised.

In the English provisional specification of J. H. Johnson, December 24, 1878, while the inventor contemplated the raising of the potential in his converters, yet he says, "the apparatus may be connected together * * * in such manner as to augment either the tension or the quantity of the current."

Thomas A. Edison took out a patent, May 29, 1883 (the application having been filed August 14, 1882), for an apparatus for translating electric currents from high to low tension. In his invention he uses a continuous current of high tension in the main circuit, and reduces it to a continuous current of low tension in the secondary circuit.

This incomplete review of the prior state of the art would seem to show that, at the date of the article in *Engineering*, there was no invention in a single converter which transferred energy from high to low potential, as distinguished from a conversion from low to high. It seems to have been assumed in prior patents as a matter of common knowledge that, by the laws governing the inductorium, or converter, the electric force transferred could be either of the same potential or of greater or less, as might be desired. It required something further, something that might be called invention, to solve the problem of a successful system for electric distribution. Gaulard and Gibbs undoubtedly believed that, in the article in *Engineering*, they unfolded to the world a description of a successful system. So far as their system was a new invention, and is found incorporated in the patent in suit, they are entitled to be protected. But they are expressly limited by their disclaimer to the series system, and, therefore, the defendants who use the multiple arc system do not infringe.

Without entering further into the defenses raised, I am satisfied, for the reasons given, that the bill should be dismissed.

Bill dismissed.

THE CUSHMAN TELEPHONE CASE.

The following is an abstract of Judge Blodgett's opinion in his decision against the Cushman company, July 20, noticed in the ELECTRICAL ENGINEER for August:

"The questions presented are purely questions of fact. If Dr. Cushman did actually produce and put in use, to the extent claimed by him, the apparatus constructed, as described by him, so as to transmit articulate speech to a distance by means of an electric current, then, I should think there would be no doubt that such fact should defeat the Bell patents, as the apparatus described by Cushman is conceded to be substantially identical in principle, construction, mode of operation, and result with the Bell devices. It is conceded that in order to defeat a patent by proof of prior knowledge and use of the device covered by the patent, such proof must be so clear and satisfactory as to leave no room for reasonable doubt.

"It is not my purpose to go into a complete analysis of the voluminous proofs in this case. It is sufficient to say that there is no proof in the records, save from Dr. Cushman himself, of the construction and use of the first apparatus described by him, through which he heard in the office at Racine the peeping of frogs in a swamp several miles away, and which, as he says, led up to the experiments which he, with the assistance of his brother, W. P. Cushman, and B. T. Blodgett made the operative telephone of 1851. The evidence in this case is quite convincing

that such an apparatus as he describes his lightning-arrester to have been would not transmit the peeping of frogs or articulate speech, as the glass plate which he says covered the top would have entirely excluded the sounds from the magnets.

Both W. P. Cushman and B. T. Blodgett, who it is claimed, aided in the construction of the four talking boxes in the summer of 1851, are dead, and the only witnesses aside from Dr. Cushman himself are the workmen said to have been employed in putting up the telegraph line from Racine westward. I think there is nothing shown by their testimony to have been accomplished by these experiments which could not be attributed to the action of a device operating as an acoustic telephone or the ordinary relay telegraph instrument then in use to transmit signals by clicks. That some kind of experiments were made in the presence of these witnesses is probably true, as I can not believe that these men would intentionally swear falsely, but I do seriously doubt whether they witnessed at that time all the results to which they now testify. After these experiments upon the line, we have the line from the back room of the Racine telegragh office and from White's shop to Wright's carpenter shop, and the experiments there. That such a wire was run from one or both these places I can not doubt, and I think it possible that some words may have been transmitted from one end to the other of this wire; but this result can easily be accounted for by the action of the device as a simple acoustic telephone, as the line ran direct from one point to the other, and the distance was only about 300 feet.

"The next alleged use is that of the wires between Dr. Cushman's house in Racine and the farm of W. P. Cushman, six miles away. The proof as to this use rests upon the evidence of Dr. Cushman alone, and I do not think the attempted corroboration of his testimony by Josiah B. Cushman's testimony is reliable. The practical use of these 'talking boxes,' in 1854 and 1855, does not show results which may not have been obtained by the acoustic telephone.

"My conclusion from a careful reading and consideration of this mass of testimony is that Dr. Cushman, with the aid of W. P. Cushman and B. T. Blodgett, in Racine, during the summer of 1851, did make a device containing magnetic coils through which spoken words could be and were transmitted at short distances; that the transmission was faint and the words difficult to hear, and the attempt to talk through them was often a total failure, and occasionally when all conditions were favorable, only a partial or meagre success was obtained. * * * I have no doubt from the proof that the machines made by Dr. Cushman, W. P. Cushman, and B. T. Blodgett in 1851 were in all practical respects as good as any that were made afterwards by Dr. Cushman or those who assisted him. Orrin White tried to improve them, and afterward Joshuah B. Cushman made an effort in the same direction, but they were so imperfect in their operation as to offer no promise to anyone of their future possibilities. These considerations compel me to the conclusion that all the testimony, when taken together, falls short of establishing beyond reasonable doubt the fact that Dr. Cushman in 1851 invented the telephone, and what was done by him must and should be treated as at best only an abandoned experiment.

"I do not think the testimony when fairly considered shows that Dr. Cushman produced at Racine or elsewhere prior to the invention of Bell a practical, operative telephone of any kind. He gave the world nothing—what he did, if he did anything but make an acoustic telephone—was suffered to die in embryo or germ, before any valuable or useful fruition. I do not believe the machines made by him during these experimental years were so far perfected as to be of any practical value, or to even suggest that they might be so improved as to become valuable and useful. If a word could be occasionally transmitted through them, the result seems only to have excited curious wonder in the south, and did not challenge the attention of practical men, as did the first exhibitions of the Bell device. When the Bell telephone was brought to the attention of the public its value and utilities were grasped at once. It was accepted as a great invention by the general public as soon as its operation was seen, and I can see no reason why the public would not as readily have comprehended its advantages and value in 1851 as in 1876, had the machine been so far developed as to give substantial promise of what Bell accomplished."

SEMI-ANNUAL CONVENTION OF EDISON COMPANIES.

The association of Edison illuminating companies met Wednesday, August 8, 1888, at Nantasket hotel, Nantasket Beach, Mass., in their eighth semi-annual convention. The total number of representatives present during the sessions of the convention amounted to sixty members. Several other gentlemen were present by invitation during some of the sessions.

New York city was fairly well represented by E. H. Johnson, J. H. Vail, W. J. Jenks, respectively the president, superintendent, and municipal department manager of the Edison Electric Light company in the metropolis; electricians Chas. Wirt and H. T. Edgar, and expert L. Steininger; John I. Beggs, vice-president and general manager of the Edison Illuminating Co.; C. J. Field, chief inspector Edison United Manufacturing Co. and J. W. Schrorder.

Other delegations were as follows:—

Boston: C. L. Edgar, superintendent of the Edison Illuminating Co., S. B. Paine, A. S. Knight, and Hubbard Breed, who is the treasurer of the company with which Mr. Edgar is connected.

Elgin, Ill.: Chas. Westervelt, the Edison company's general manager.

Wyoming: R. M. Jones, general manager of the Laramie Electric Lighting Co.

Brockton, Mass.: G. W. Palmer and W. L. Garrison.

Other Massachusetts delegates were Albert F. Dow and J. H. R. Ward of Fall River; C. E. Price, New Bedford, Wm. M. Brock and G. W. Russell, Lawrence.

General manager A. M. Renshaw, Washington, D. C., was the only registered representative from that city.

Magnus Pflaum, McKeesport, Pa.; H. Ward Leonard, of Leonard & Izard, Chicago; F. G. King and A. L. Smith, Appleton, Wis.; Jno. R. Markle, C. P. Gilbert, Detroit; Wilson S. Howell, New Brunswick, N. J; F. E. Jackson, B. F. Card and F. R. Upton, Harrison, N. J.; president Thomas P. Merritt and secretary F. N Boyer, Reading, Pa.; president Geo. H. Kirchway and director H. L. Browning, Albany; manager W. L. Turner and treasurer F. E. Drake, Columbus, O.; manager E. H. Brooks, Lebanon, Pa., superintendent J. E. Giles, Hazleton, Pa.; superintendents E. B. Greene, Altoona, Pa., and H. K. McKay, Birmingham, Ala.; Samuel N. Frump, J. A. Lightipe and F. L. Gilpin, Wilmington, Del.; manager J. B. G. Roberts and superintendent Maurice Hooper, Westchester, Pa.; secretary H. Brewster, Rochester, N. Y.; superintendent J. S. O'Brien, Wilkesbarre, Pa. Others at the hotel and present at some of the meetings as delegates or in other capacities were general agent H. McL. Harding, of the Sprague Motor Co.; W. A. Hill, W. H. Atkins, E. L. Caldwell; H. H. Niles, A. O. Shepardson, W. H. Francis, W. D. Marks, Philadelphia, J. R. McLaughlin, Detroit, Chas. Hewitt, Patterson, N. J., N. C. Martin of New York, and W. I. Barker, Boston, both of the *Electrical World;* secretary F. J. Boynton of Boston; R. F. Ross, *Modern Light and Heat*, Boston; Capt. Brophy, B. F. Simmons, and F. C. Lockwood, representing the *Western Electrician.*

The meeting was called to order by the president, John I. Beggs, at 11.30 A. M., and in opening the convention he congratulated the association on the large number of representatives, and the very numerous companies represented.

Some interesting load diagrams showing comparisons of load variations at Columbus, Ohio, were presented by Mr. Turner, manager of that company.

Electric motive power and its widely increasing application was then discussed.

At the afternoon session of Wednesday, new officers of the association were elected for the ensuing year as follows:—

President, John I. Beggs; vice-president, C. P. Gilbert; secretary, J. H. Vail; treasurer, Wilson S. Howell; executive committee, A. L. Smith, F. R. Upton, C. L. Edgar, J. P. Merritt, R. M. Jones.

At the evening session the association and visitors were entertained by a very able and exhaustive paper, presented by W. J. Jenks, on the subject of lightning and its effect on electric light, telephone and telegraph systems. This paper was splendidly illustrated by numerous stereopticon views. This was followed by a series of stereopticon views exhibited by Mr. Harding, showing the principal features of the Sprague system of electric railways, as well as interesting and novel applications of motive power.

At the opening of the session on Thursday, a paper was presented by Mr. Jackson, assistant electrician of the Lamp company, on the subject of the high economy municipal lamp and the result of its application in Edison stations. This was followed by an address by Mr. Upton on a similar subject.

A paper on the subject of feeder equalizers and regulation of electrical pressures on the three-wire system was presented by Charles Wirt. This was followed by another paper by H. Ward Leonard on the subject of proportioning conductors in the system of electric light. Both of these papers were very accurate and to the point, and showed a comprehensive grasp of the different questions involved.

Another interesting report was made by Mr. Jenks on the growth of the Edison municipal system. Mr. Jenks also gave a summary of the work done by the standardizing bureau of which he is director.

Several interesting discussions were had on the enlarging field for applied electricity, and other subjects of importance to the association.

The executive committee reported that they had selected Kansas City as the best locality for the next meeting of the association. This selection was approved, and the convention adjourned to meet in six months.

. . . . THE only right way to put up an installation is to reduce all chance of a mishap to a minimum by putting in the best possible work.—*J. A. Jeckyll.*

A DECISION IN THE PATENT SUIT OF ROOSEVELT *vs.* LAW TELEGRAPH CO.

In the suit of Roosevelt *vs.* The Law Telegraph Co., a decree was recently issued by the United States Court in favor of the plaintiff.

The above suit was brought for infringement, by what has been known as the "Law Battery," on the Leclanché patent of November 16th, 1880, which covers the "Gonda" Prism battery manufactured by the Leclanché Battery Co. The opinion of the Court is an exhaustive one, covering every point in the case, and sustaining the Leclanché patent in a very broad sense. Injunction has been issued against the manufacture and sale of the said "Law Battery."

MISCELLANEOUS.

FOUR of the largest manufacturers of copper wire for electrical purposes in the United States used in 1887, 13,500,000 pounds of copper.

THE WESTERN UNION operating room at 195 Broadway now contains 505 desks, exclusive of those in the Commercial News department, and above the switch-board. There are 800 employés on the pay roll of the operating department.

THE ELECTRICAL COURSE AT RUTGERS COLLEGE.

The trustees of Rutgers College have decided to establish an electrical course in the scientific school of the college.

This course is parallel with the other four-year courses of the school, and those who complete it receive the usual degree of Bachelor of Science.

The studies include mathematics through surveying; a full course of chemistry with laboratory practice, embracing qualitative analysis and the elements of quantitative analysis; physics, using the latest edition of Ganot in the original French, and such works as Stewart and Gee for physical laboratory practice. A select course of draughting in the first year, and extensive drill in the use of tools during the second year are preparatory to construction of apparatus later on. The works of Cumming, Kempe, and others of a specifically electrical character, are used in the third and fourth years, in conjunction with treatises on the various prime movers.

Natural history; the usual English branches; mental and moral philosophy; French; German; composition and speaking; and extemporaneous debating are included in this course, to insure a rounded development. The purpose is not to graduate electrical engineers, but men fitted to pursue distinctively electrical occupations, with a good general basis. A good amateur workshop and a physical laboratory are to be fitted up, and special stress will be put on ability to manipulate well. The course in general physics will include a thorough drill in problems, particularly such as enforce fundamental principles, and students will be required to use French and German freely.

The preparations are already sufficiently advanced to fulfill requirements of the first year, and there is a good prospect that ample accommodations will be ready for pupils at the successive stages of the course. No *special* students are desired, but every one is expected to take the full curriculum.

ROSE POLYTECHNIC INSTITUTE.

The Rose Polytechnic Institute, is one of a number of schools in the United States which are especially devoted to the education of civil and mechanical engineers. It owes its existence to the generosity of the late Chauncey Rose, of Terre Haute, Ind., who bequeathed something more than a half million of dollars for its establishment and support. It is one of the youngest of the technological schools of the country, having been opened for instruction in the year 1883. One of the peculiar features of the institute is the extensive "shop practice" of the students in mechanical engineering. Not only are machines designed and working drawings made, but actual construction is required and is made possible in extensive workshops, the equipment of which has cost over forty thousand dollars.

Especial attention is given to the study of electricity and its applications, for which excellent facilities are provided in the equipment of the extensive laboratories.

The plan of the institute is to restrict the attendance to such an extent as to realize the benefits arising from small classes.

ADDITIONAL RULES OF THE NEW YORK BOARD OF ELECTRICAL CONTROL.

The following were added to the Rules and Regulations of the Board of Electrical Control, July 2d, 1888:—

Day circuits.—All circuits which ever carry a current exceeding 500 volts, between 9 A. M. and 4 P. M., must be painted red for a length of two feet at each insulator.

Number of circuit.—Every electric light wire carried on poles must be indicated by a number plainly marked on each cross-arm under the insulator.

Stations.—All circuits must be tested every hour when in operation, and when a ground comes on, effort must be made to remove it at once; failing in this, the current must be discontinued until the insulation is restored.

Certificate of inspection.—From and after the first of August, 1888, no company shall do business of arc electric lighting in the City of New York without a certificate of the board, granted on the recommendation and after inspection by the expert of the board, to the effect that its lines comply with all the rules and regulations of the board, and that its plant is in proper condition for the doing of its business. The force of the certificate to continue until changes are made, of which the board must be notified and approve, or so long as the plant and conductors remain in the same condition as when inspected.

The following were added to the Rules and Regulations of the Board of Electrical Control, July 16th, 1888:—

Loops.—No unused loops from electric light circuits shall be allowed to remain after lamps are taken away, except in cases where it is positively known that the lamp will be required again within three months, and where there is no underground conduit for that class of circuits.

Linemen.—All linemen must wear a badge, in a conspicuous place, giving the name of the company by whom they are employed, and a number.

TESTS OF A SPRAGUE AND AN EDDY MOTOR.

BY FRANK P. COX, B. S.

SPRAGUE MOTOR.—1 H. P.

Current	8.29
Potential	117.84
Electrical horse-power	1.31
Mechanical horse-power	1.06
Efficiency	81%

EDDY MOTOR.—½ H. P.

Current	17.99
Potential	27.76
Electrical horse-power	.669
Mechanical horse-power	.43
Efficiency	64%

Thomson's graded galvanometers were used for determining current and potential; a Tatham dynamometer to determine the mechanical horse-power.

SOME NOTABLE DYNAMO TESTS.

A test is reported of an Edison-Hopkinson dynamo, made by Mather & Platt, of Salford, England, of a type giving 320 amperes and 110 volts at 780 revolutions, which gave a commercial efficiency of 93.23 per cent.; loss in core 1.94; in field 1.66 and in armature 3.17. The same machine, used as a motor gave an efficiency of 93.79, and on the double conversion an efficiency of 87.05 was obtained, excluding loss in leads. The Manchester dynamo; a compound wound machine of the same makers, but of a different type, gave a mean result of a number of trials, of 77.5 per cent. double conversion over a distance of 100 yards.

A NEW INSULATING COMPOUND.

A new insulating material, described in the *Chronique Industrielle*, has just been produced. It is composed of one part Greek pitch and two parts burnt plaster, by weight, the latter being pure gypsum, raised to a high temperature and plunged in water. This mixture, when hot, is a homogeneous, viscous paste, and can be applied with a brush, or cast in molds. It is amber colored, and possesses the insulating properties of ebonite, and can be turned and polished. Its advantage is its endurance of great heat and moisture without injuring its insulating properties. —*Electrical World.*

THE TELEPHONE.

THE AMERICAN TELEPHONE & TELEGRAPH CO.'s long-distance lines seem to be proof against the storm blasts of summer as well as the blizzards of winter. Not a single private wire has been interrupted during the recent wind storms; another proof of superior construction.

THE next meeting of the National Telephone Exchange Association will be held in the City of New York, at the Hotel Brunswick, commencing Tuesday, September 4, 1888. The hotel is on the European plan. Rooms may be engaged direct, or the secretary will cheerfully attend to such business on request of any member of the association.

THE SOUTHERN NEW ENGLAND TELEPHONE COMPANY is to put up a large building on Court street in New Haven. It will contain, besides the Central and Telephone Exchange, the executive offices of the company and a public telephone station. The change will materially improve the service.

THE life saving stations along the south coast of Long Island

are all to be connected with each other by telephone, and those isolated from the mainland are to be connected with the nearest village. Surveyor Boland, of the treasury department, is at present making a survey for the laying of a cable between Montauk Point and Rockaway Beach. The work will probably be completed by October 1.

THE office of the secretary of the National Telephone Association is now in room 512, 18 Cortlandt street, New York city (the Metropolitan Telephone Co.'s building). The treasurer's office remains in room 501 of the same building. Telephone call "531 John."

DURING the agitation at New Orleans, La., regarding the ordinance regulating the telephone charges at $50 a year, the representatives of the telephone interests did not think the city had power to regulate the price of telephones under existing ordinances, and thought that the present price is a fair one considering that this climate is more dangerous to the apparatus than that of other large cities. The following comparative table of rates was made up from information obtained by the committee on fire and lighting, the telephone company and the Chamber of Commerce:

Chicago	$125	St. Louis	$100
Philadelphia	120	New Haven......50 to	75
Baltimore	100	Washington	100
Cincinnati	100	San Francisco..60 and over	
Atlanta	60	Pittsburg..........84 to	600
Cleveland	180	Boston	120
Milwaukee......60 to	100	Rochester	64
Kansas City	72	Brooklyn	120
New York.......150 to	180	New Orleans	96
Louisville.........72 to	96		

The committee did not see its way to report favorably upon the ordinance, but thought that stirring up such matters did good, as bringing about the obtaining of useful information.

LIGHTNING CONDUCTORS TO BE DISCUSSED BY THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

It is announced that the organizing committees of Sections A and G of the British Association for the Advancement of Science, have arranged a joint discussion on "Lightning Conductors," to be held at the Bath meeting, in September. Mr. W. H. Preece, F. R. S., will open the discussion, and Professor Oliver J. Lodge, D. Sc., F. R. S., will defend the position he advocated this year before the Society of Arts.

AN ELECTRIC RAILWAY FOR LONDON.

At a meeting of the shareholders of the City of London and Southwark Subway Co., held at Winchester House on Tuesday, the directors were authorized to make arrangements for the working of the line by electricity. The subway, which, when complete, will extend from the city side of London bridge to the Swan at Stockwell, with several stations between those two points, was originally intended to be worked on the endless cable principle, which is said to give such satisfactory results in America, but the directors of the company have, after careful investigation, arrived at the conclusion that the line can be more thoroughly, efficiently, and economically worked by electricity. Several eminent firms have, they say, expressed their readiness to undertake the work, the system which they propose to adopt being that of continuous conductors, and are so sanguine of success that they have offered to work the line on favorable terms for a number of years. One or two of the shareholders present evinced opposition to the action of the board in discarding the original idea of a cable, for what, in their opinion, was the more risky electrical system, but eventually the resolution proposed by the chairman was sanctioned. It was stated during the proceedings that the engineer hopes to get that portion of the subway between the city and the Elephant and Castle completed by the end of the year.—*The Telegraphic Journal and Electrical Review* (London), Aug. 17.

BRITISH EXPORTS OF TELEGRAPHIC WIRES, &c.

The satisfactory features of the board of trade returns for July, issued on Wednesday last, are not reflected in the exports of telegraphic apparatus. The exports of metals, ironwork and machinery were exceptionally favorable both for July and for the previous six months, but the exports of telegraphic wire and apparatus were exceptionally small. The following is a comparative statement to date:—

Exports of telegraphic wires and apparatus connected therewith.

	1886.	1887.	1888.
1st Jan. to March 31st	£124,074	£131,879	£88,077
1st April to June 30th	354,331	56,933	156,136
Six months	478,405	188,812	244,213
July	219,463	195,950	21,571
Seven months	£697,868	£384,762	£265,784

The July exports this year have been almost the smallest of any month so far, while in 1887 and 1886 the July exports were up to date by far the largest.—*The Electrician* (London), Aug. 10.

ELECTRIC LIGHT AND POWER.

THE WHITIN MACHINE CO., Whitinsville, Mass., have increased their electric plant, adding 135 arc lights. The Waterhouse Electric & Manufacturing Co., of Hartford, Conn., were given the order, as the plant installed by them last season was entirely satisfactory.

THE WESTERN ELECTRIC CO. of Chicago, is installing an arc light plant for the Brown Bros. Manufacturing Co., Chicago.

AT Urbana, the common council has awarded to the Excelsior Electric Co., F. W. Horne, Chicago western agent, the contract for installing a 120 arc light plant in the city.

THE WILLIMANTIC ELECTRIC LIGHT CO., Willimantic, Conn., have again increased their plant with 35 Waterhouse arc lamps and another dynamo.

THE OREGON IMPROVEMENT CO. have ordered for their wharves, machine shops and railroad station a Waterhouse arc and incandescent plant.

THE FORT WAYNE JENNEY ELECTRIC LIGHT CO. is building a very large lighting station in this city, near 80th street and Avenue A, East River.

SAN DIEGO, Cal., has adopted the Westinghouse system of incandescent light, and the plant has been ordered. The capacity will be 1,300 lights, and it is expected the town will be lighted about October 1st.

THE WESTINGHOUSE ELECTRIC CO. has taken up the alternate current motor of Mr. Nikola Tesla, and has now for some time been carrying on experiments under the supervision of the inventor looking to the commercial development of the motor. The results already accomplished are, it is understood, very satisfactory indeed, and this remarkable invention is likely to be embodied in practical work-day motors at an early day.

ON seeing the Waterhouse light recently installed for the Joliet Electric Light Co., Joliet, Ill., the Joliet Steel Co., placed their order for an arc and incandescent plant with the Waterhouse Electric and Manufacturing Co., of Hartford, Conn. The Waterhouse incandescent system has been ordered for the lighting of a fashionable seaside resort in England.

THE general offices of the Consolidated Electric Light Co. and of the Sawyer-Man Electric Co. have now been some weeks established in their new premises at 510 West Twenty-third street, New York, to which address all communications should be sent.

The office of H. R. Garden, vice-president and general counsel, will remain in the Mutual Life building, 32 Nassau street.

THE AMOSKEAG MANUFACTURING CO., of Manchester, N. H., may be said to have "a large and well-selected assortment" of electric lighting machinery. The outfit consists of five No. 8 Brush dynamos, and five No. 7, with an aggregate lighting capacity of 370 lights of 2,000 candle-power; 21 Weston 10-light dynamos of 2,000 candle-power each; one Thomson-Houston 45-light dynamo of 1,200 candle-power; one 300-incandescent light Edison dynamo; one 75-light Forsaith, and one American 50-light machine. Three of the Brush dynamos of the No. 7 pattern have been in use in the No. 4 mill as long as any such machine in the state, and are still in very good condition. One of the Weston dynamos has been in operation seven and one-half years, and still gives excellent satisfaction.

THE NEW ENGLAND INSURANCE EXCHANGE recently issued the following circular:

To Companies and Agents:

Following is a complete list of electric light companies, or "systems," that have complied with all the requirements of this "Exchange," and whose installments and apparatus will entitle the assured to rebate in tariff rates, in accordance with vote of March 31, 1888, heretofore promulgated.

No allowance will be made for the apparatus of any company or system not named in the following list:

American Electric Manf'g Co., Ball Electric Light Co., Bernstein Electric Light Co., Brush Electric Light Co., of Cleveland, Ohio; Edison Electric Light Co., Edison United Manf'g Co., Fred. M. Kimball & Co., of Boston; Loomis Electric Light Co., Mather Electric Light Co., Sawyer-Man Electric Co., Schaefer Electric Manf'g Co., Sun Electric Light Co., Thomson-Houston Electric Co., Tremont Electric Lighting Co., United States Electric Lighting Co., Waterhouse Electric and Manf'g Co., Westinghouse Electric Light Co. Respectfully, ARTHUR A. CLARKE.

S. E. BARTON.

Foreign.

Austria.—Some time ago the proposal of Messrs. Siemens and Halske to establish a central electric light station in the very heart of Vienna was reported. Work has since then steadily progressed, and the firm have now invited householders in the district to send in particulars of their requirements for light. The concession was given on condition that the contractors would not

charge more than 2.75kr. per lamp hour, but in order to get sufficient custom they will very probably have to lower the price. Curiosity prevails in electrical circles as to how low the charge will have to be fixed in order to induce a sufficient number of the somewhat conservative householders of the inner town to become subscribers. The next central station will be that in Mariahilf. The distribution will be on the direct low pressure system, and will have to compete with another central station projected by Messrs. Ganz & Co. for the same locality, where the distribution will be by means of transformers. Some activity is also displayed by the Deutsche Allgemeine Elektricitäts Gesellschaft, of Berlin, who are contemplating the erection of a branch establishment in Vienna for the general supply of electricity.

Cuba.—The Havana Electric Light Co., of Jersey City, has been incorporated by J. del Calvo and others, with a capital stock of $15,000.

France.—ELECTRIC LIGHT INSTALLATION AT TOULOUSE.—An electric light installation has just been erected by the Toulouse Gas Co. in the Theâtre du Capitole in that town. Current is supplied by two 500-light Breguet dynamos, each being driven by a two-cylinder Otto gas engine of 50 h. p. The dynamos and gas engines are placed in a cellar situated a short distance from the theatre. There are 1,000 lamps of 10, 16 and 20 c.p. installed, and they have been fixed to the existing gas fittings. The lamps are supplied from two circuits, which are so arranged that should an accident happen to one, the lamps in the other will not be extinguished. The lighting is said to be very satisfactory, and the installation has been carried out under the superintendence of M. Brouardel, manager of the Compagnie Française du Centre et du Midi.

Germany.—UNDERGROUND CABLES IN BERLIN.—Some time ago a committee was appointed in this town to carry out a comprehensive series of experiments with underground cables as used for electric lighting urposes. The experiments were made partly with sections of cables used in the various central station supply systems, and partly with cables specially laid for the purpose in the works of Messrs. Siemens and Halske. The experiments are now nearly completed, and the results will be communicated at an early date in the form of a paper on underground conductors to the Berlin Society of Electricians.

THE SUPPLY OF MOTIVE POWER FROM CENTRAL ELECTRIC LIGHT STATIONS.—The Berliner Elektricitäts Werke are now supplying current for driving electromotors. They have issued a circular to their customers, pointing out that the capital outlay for an electromotor is less than that for an equivalent steam or gas engine, whilst the expense for attendance and water is entirely avoided. The cost of lubricants is also greatly reduced. The company are ready to supply current for motors varying in size from $\frac{1}{16}$ h. p. to 12 h. p. The maximum current required for a $\frac{1}{16}$ h. p. motor is 1 ampere; for a $\frac{1}{4}$ h. p., 3 amperes, for a $\frac{1}{2}$ h. p. $5\frac{1}{2}$ amperes; for a 1 h. p., 10 amperes; for a 5 h. p., 45 amperes; and for a 12 h. p., 105 amperes. If the customer requires the motor during the day time only the charge for current is the same as where the current is used for lighting; but if the motor be required from sundown till eleven at night the company reserve to themselves the right of making an additional monthly charge of 1s per ampere, should the exigencies of the lighting service render it necessary to place this restriction upon the use of motors. On the assumption that the motor is in use for 3000 hours annually, the cost of 1 h. p. hour varies from $5\frac{3}{4}$d. for the smallest motor to $3\frac{1}{4}$d. for the largest. For a 2 h. p. motor the cost is about $3\frac{1}{2}$d. per horse-power hour.—*Industries.*

New Zealand.—The city couucil of Wellington has accepted the tender of the Gülcher Electric Light Co., of London, for machinery, buildings and plant for lighting the city with 480 Edison-Swan lamps, each of 20 c. p. The contract price is £1,750 per annum for the first five years, and an offer was made to run on for another five years at £1,600 per annum, should the council not decide to purchase the plant at the end of the first period. The Gülcher company was, we are informed, the only one tendering, although the matter was freely advertised in England, America and, we believe, on the continent.

PERSONAL MENTION.

DR. BENJAMIN FRANKLIN GOODRICH, president of the B. F. Goodrich Co., and the Goodrich Hard Rubber Co., Akron, Ohio, died August 3d.

MR. L. D. WAKEMAN has been engaged by the New York State Agency, of the Sprague Electric Railway & Motor Co., to look after its interests in the city of Buffalo.

MR. T. C. HATHAWAY, JR., of New Bedford, Mass., a graduate of the Massachusetts Institute of Technology, is under engagement with the New York State Agency of the Sprague Electric Railway & Motor Co., and is located in central New York.

MR. WILLIAM D. HIGGINS, who was recently engaged as special agent of the Sprague Electric Railway & Motor Co., has been placed in charge of the Buffalo office of the New York State Agency, Edward E. Higgins, manager.

MR. J. HOWARD PRATT, JR., late Instructor in Physics at Cornell University, has been appointed Professor of Physics and Mathematics in Illinois College, Jacksonville, Ill. Mr. Pratt will assume his new duties at the beginning of the college year in September, and in view of his known interest in electricity, together with his wide acquaintance with its science and the arts built upon it, we may predict that that department of physics will be ably presented to the students at Jacksonville.

THE NEW YORK STATE AGENCY, recently established by the Sprague Electric Railway & Motor Co., with headquarters in Buffalo, is working up a large amount of business both in railway and stationary work. Its manager, Mr. E. B. Higgins, reports the interest in electrical transmission of power to be unexpectedly great, and the prospects for immediate work are very encouraging. The agency has just sold a 5-h. p. Standard motor to be used in the large dry goods establishment of Barnes, Hengerer & Co., of Buffalo, for running a large number of sewing machines. Current will be supplied by an Edison dynamo used in lighting the building.

MR. ELIAS E. RIES, of Baltimore, has been spending some time in Boston, where he is looking after his electrical interests. Mr. Ries exhibited there a very interesting working model of his electric traction increasing apparatus for street railway motors, an invention which is eliciting considerable attention on the part of electricians and those interested in street railways. By the aid of this invention, street cars operated by electric motors are said to be able to climb grades as steep as 15 to 20 feet in 100, without the slightest difficulty. A very ingenious and effective system of braking is also employed in connection with the traction increasing apparatus, by means of which it is possible to stop a car running at full speed down a steep grade within a very short distance. The cars on the working model ascend and descend grades of 45 per cent. with ease; and in the case of the street car model, the magnetic adhesion between the wheels and rails seemed not appreciably affected by placing oil, mud or water upon the track. Many gentlemen largely interested in street railways from various parts of New England, have examined the models.

MANUFACTURING AND TRADE NOTES.

W. S. HILL, 13) Oliver street, Boston, manufacturer of electrical apparatus, issues a circular and price list of dynamos, motors, arc and incandescent lamp switches, fitting, etc.

THE SPRAGUE CO., have just sold one 20 and one 30 h. p. motor, to parties in Nebraska, to be used in operating machinery for making brick.

THE SPRAGUE COMPANY have received from Tokio, Japan, a very commendatory account of the performance of an electromotor fire pump, supplied by them some time since for use in the Imperial palace.

MESSRS. CHAS. A. SCHIEREN & CO., of New York, have recently opened a branch house at 46 South Canal street, Chicago, where they carry a full line of their goods. Standard, short lap, electric, and leather link belting; also raw hide and tanned lace leather.

Mr. Emil Gabel, formerly president of the Gabel Belting Co., of Chicago, has charge of this branch.

MESSRS. B. S. HALE & SON, Malden, Mass., and 16 Dey street, New York, manufacturers of insulated wires since 1857, announce in their price list No. 32, that they have added to their works facilities for winding magnets. They offer to wind bobbins to any desired resistance at prices very little in excess of the cost of the insulated wire.

THE SHAVER CORPORATION'S recent circular brings to mind the very considerable extent to which mechanical telephones are used for short lines. Mr. Shaver has given much time and energy to the development of his apparatus, and the corporation offer their telephones with much confidence and with many testimonials to their usefulness.

A LARGE BELT.—The Shultz Belting Co., of St. Louis, Mo., has just made and put into the plant of the East River Electric Light Co., New York city, one of the largest belts ever made in this country, and the largest ever made west of New York. It is 123 feet long, 58 inches wide and weighs 1,300 pounds. It is made of double leather, and is to transmit 1,000 h. p. The company made the belt, delivered it in New York, and had it transmitting power inside of six days.

This speaks well for the fulled leather (rawhide) belting made by this company. This belt was cemented only, no pegs or rivets being used at the joints.

MESSRS. CHAS. A. SCHIEREN & CO., say, "Information has reached us that attempts have been made to imitate our celebrated "electric" leather belting, and we take this opportunity to inform our patrons and the trade generally that we have the exclusive right to use the word "electric" as applied to leather belting. This right is granted us by registration in the Patent Office of the United States of America, dated November 17th, 1885, and numbered 12,785, and we hereby notify infringers that they will be prosecuted according to law.

THE NEW YORK STATE AGENCY, Sprague Electric Railway and Motor Co., has secured the services of Mr. C. H. Maclilie, of Chicago, Ill., to act as its representative in Eastern New York. Mr. Maclilie has had a large experience and has held important and responsible positions in the electrical field. Mr. Higgins is to be congratulated upon his success in securing, in so short a time, such an efficient and able staff of representatives.

OKONITE.—*The Electrical Review*, London, of June 9 last, contains a lengthy notice of this relatively new American insulating compound. After quoting the reports of several American electricians upon its properties, the writer says: "As regards the electrical and mechanical properties of "okonite," an exhaustive report by Dr. John Hopkinson, F. R. S., gives some information. The tests given by Dr. Hopkinson are remarkably good, but the results obtained by him are best given in his own words: 'Summary.—Shortly, my tests on these samples of Mr. Smith's insulated conductors prove that the insulation is practically perfect, both for high and low potentials, it is at least equal to the best G. P., and that the insulation will stand very rough handling, and a considerable temperature without injury, indeed, with a quite insignificant reduction of the insulation resistance.'" The article concludes as follows:—

"For ordinary telephone work we think that the inductive capacity and the amount of covering required are rather against the adoption of okonite, but for general telegraph work, especially for 'leading in' at stations, signal boxes, etc., this core will be specially valuable. Its mechanical properties, high insulation, and indifference to heat, render it a very efficient core for electric light purposes, and we should not be surprised to see it used largely for such positions and places where most insulated wires have hitherto proved failures."

THE BALL ELECTRIC LIGHT CO. (Limited), of Canada,—headquarters, Toronto, are introducing the Ball system in the British Provinces. They have recently issued a descriptive and illustrated circular, in which they lay special emphasis on their small arc lamps, called the "Ball subdivided arc light."

THE ELECTRIC WATER PROTECTIVE CO., 713 Broadway, New York, invite inspection of their protective system in operation at the above address,

MR. JARVIS B. EDSON'S last pressure recording gauge circular affords evidence of the large and widely extended use of his gauges. Fac-similes are given of many records obtained in actual service. The circular also includes instructions for the proper use of the recording gauges. Mr. Edson's devices were among the earliest in the class of practical apparatus for recording forces, consumption of material, and the like. When such records can be reliably made they seem scarcely less important in industrial work than records of wages or other money expenditure.

ELECTRIC STREET RAILWAYS IN AMERICA

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horse-power; **T.**, T rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scaife; *Sec.*, Arthur Kennedy; *Tr.*, Jas. B. Scott; *Supt.*, Alexander Moffat; *Eng.*, ——; 3-7 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 200 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½; 45 lb.; 3 m. c.; 1 m.; sta. —— h. p.; overhead cond. THOMSON-HOUSTON.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Tr.*, F. W. Harriman; *G. M.*, A. A. Jöhnson; *Eng.*, N. M. Edwards; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; sta., 60 h. p.; water power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g. 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Birmingham, Ct.—Derby Horse Railway Co.—*Pr.*, H. H. Wood; *Sec.*, Wm. J. Clark; *Treas.*, Chas. E. Clarke; 4 mi.; 94' 8½"; m 5; c. 4; h. p. 100. VAN DEPOELE.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; *G. M.*, John Aldrich; 5 mi.; g. 4-8½; 30 and 60 lb.; 3 m. c.; 1 m.; steam power; sta. 75 h. p.; overhead cond. SPRAGUE.

Columbus, O.—Columbus Consolidated Street Ry. Co.—*Pr.*, A. D. Rodgers; 2 mi.; g. 5-2; 2 m. c.; 30 lbs.; 2 c.; sta., 250 h. p.; underground conduit. SHORT.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. THOMSON HOUSTON.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g. ——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE. Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; *Supt.*, Mr. Richardson; 1 mi.; g. 5-2; 35 lb.; 2 m. c.; sta. 40 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1 c.; 1 m.; sta. —— h. p.; conduit VAN DEPOELE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, D. W. Burdick; *Sec.*, J. Murray Mitchell; *Tr.* T. F. Van Fleet; 1 mi.; g. 4-8½; 30 lb. T.; 2 m. c.; sta. 20 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Lafayette, Ind.—Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2.25 mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 48 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Meriden, Conn.—New Horse R. R.—*Pr.*, T. J. Lathram; *Sec.* and *Tr.*, T. A. Lamb; 5 mi.; g. 4-8½; 35 lb.; 12 m. c.; overhead cond. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. THOMSON-HOUSTON.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. THOMSON-HOUSTON.

Richmond, Va.—The Richmond Union Pass. Ry. Co.—*Pr.*, W. R. Trigg; *Sec.* and *Tr.*, Andred Pizzini; *G. M.*; G. A. Burt; *Eng.* A. L. Johnston; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 400 h. p.; overhead cond. SPRAGUE.

Salem, Mass.—Naumkeag St. Ry. Co.—*Pr.*, C. Odell; *Tr.*, H. Wheatland; *Sec.*, J. F. Hickey; *Supt.*, W. B. Furgurson; 1½ mi.; g. 4-8½; 6 m. c.; 35 lb.; 80 p. c.; sta. 100 h. p.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*. Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

San Jose, Cal.—San Jose & Santa Clara R. R. Co.—*Pr.*. S. A. Bishop; *Sec.*, E. Rosenthall; *Tr.*, J. Rich; *Supt.*, W. Fitts; 10 mi.; g. 3; 6 m. c.; sta. 130 h. p; conduit. FISCHER.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*. A. P. Friesman; *Supt.*, R. McMaugh; *Eng.*, W. S. Smith; 5.75 mi.; g. 4-8½; 30 lb.; 4c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

St. Joseph, Mo.—Union Ry. Co.—*Pr.*, Seymour Jenkins; *Sec.* and *Tr.*, A. Steinacker; *Supt.*, Chas. Wilson; 9½ mi.; g. 4-8½; 35 lb.; 8 m. c.; overhead cond. SPRAGUE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Tr.* T. F. Torrey; *Supt.* and *G. M.*. B. T. Killam; *Eng.*, J. Nazel; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 14 m. c.; sta. 300 h. p.; overhead cond. THOMSON-HOUSTON.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond. THOMSON-HOUSTON.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—*Pr.*, H. H. Sen; *Sec.*, W. E. Shupp; *Tr.*, C. Walter; *Supt.*, A. C. Robertson; 3-6 mi.; g. 5-2; 50 lb.; 3 m. c.; sta. 120 h. p.; overhead cond. SPRAGUE.

Wilmington, Del.—Front & Union St. Ry. Co.—*Pr.*, G. W. Bush; *Supt.*, S. A. Price; *Tr.*, E. T. Taylor; g, 5-2; —— lb. SPRAGUE

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.5 mi.; g. 3-6; 25 lb.; 1 c.; 1 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb. T; 1 m. c.; sta. 1,000 h. p.; overhead cond. THOMSON-HOUSTON.

Constructing or Under Contract.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—*Pr.*, H. G. Bacon; *Tr.*, J. E. Draper; *G. M.*, H. M. Daggert, Jr.; 6 mi.; g. —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond.

Boston, Mass.—West End Ry. Co.—12 mi.; 20 m. c.; overhead. SPRAGUE.

Brockton, Mass.—East Side St. Ry. Co.—*Pr.*, A. F. Small; *Clerk*, C. A. Noyes; *Tr.*, C. D. Fullerton; *Eng.*, E. L. Brown; 4½ mi.; g. 4-8½; 40 lb.; 4 m. c.; steam-power sta. 60 h. p.; overhead cond. SPRAGUE.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown; *G. M.*, E. Scott; 4 mi.; g. 4-8½; 25 lb.

Cleveland, O.—— 8 mi.; 16 m. c.; overhead. SPRAGUE.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper; *Sec.*, J. R. Murdock; *Tr.* and *G. M.*, G. B. Kerper; *Supt.*, R. Palley; *Eng.*, H. Kolf; 1 mi.; g. 5-2½; 52 lb.; 3 m. c.; 3 m. overhead.

Davenport, Iowa.—3.5 mi.; 8 m. c.; overhead cond. SPRAGUE.

Elsinore, Cal.—Elsinore Lake Shore Elect Ry. Co.—*Pr*, D. G. Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.

Erie, Pa.—Erie City Pass. R. R. Co.—*Pr.*, W. W. Reed; *Sec.*, J. L. Sternberg; *Supt.*, Jacob Borst.

Flushing, N. Y.—Flushing & College Point St. R. R.—*Pr.*, J. Dykes; *Sec.*, Charles Frey; *Tr.*, Henry Clement; g. 4-8½; 45 lb.; 1 mi.; storage bat's.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—4.5 mi.; g. 5.2½; 52 lbs.; sta. 160 h. p.; 6 m. c.; overhead cond. SPRAGUE.

Lakeside, O.—3 mi.; 2 c.; overhead cond.

Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi.; g. 4-8½; 56 lb.; 10 m. c.; storage bats.

Louisville, Ky.—Central Pass. R. R. Co.—*Pr.*, B. du Pont; *Sec.*, J. C. Donigan; —— mi: g. 5.

Meriden, Conn.—Meriden Horse R.R. Co.—*Pr.*, Geo. R. Curtis; *Sec.* and *Tr.*, C. L. Rockwell; *Supt.*, D. Barker; 5 mi.; g. 4-8; 35 lb.; 12 m. c. DAFT.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g, 4-8½; 52 lb.

New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas*. E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.

New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; conduit conductor. BENTLEY-KNIGHT.

Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; overhead cond. VAN DEPOELE.

Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.

Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Bantlug; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2¼; 47 lb.; storage.

Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, F. H. Skeele; *Sec.*, E. H. Cook; *Tr.*, C. D. Newton; *V. P.*, M. Dillon; *Supt.*, T. M. Burt; 3 mi.; g. 4-8½; 38 lb.; 5 m. c.; overhead DAFT.

Revere, Mass.—Lynn & Boston R. R.—Ocean Ave. line; overhead cond. THOMSON-HOUSTON.

Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.

St. Louis, Mo.—Lindell Ry. Co.—*Pr.*. J. H. Lightner; *Supt.*, G. W. Baumhoff; *Eng.*, E. J. Bagnall; —— mi.; g. 4-10; 65 lb.; 1 m. c.; 2 m.; 3 p. c.; storage bats.

Sacramento, Cal.—Sac. Elect. Ry. Co. The Central Street Railway Co.—*Pr.*, L. L. Lewis; *Sec.*, E. K. Alsip; *Tr.*, F. Miller; *Supt.*, J. B. Austin; *Eng.*, ——; 13 mi.; g., 4-8½. Cars to be supplied by Electric Car Co, of America, Philadelphia.

Sault Ste. Marie, Mich.—S. St. M. St. Ry. Co.—*Pr.*, E. M. Lacy; *Sec.*, F. Ryan; *G. M.*, L. G. Cody; 2 mi. FISHER.

Sandusky, O.—Sandusky Street Railway; overhead. SPRAGUE.

Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.*, A. Frothingham; *Tr.*, G. \. Jessup; *Supt.* and *Eng.*, T. Gibbs; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; steam power; sta. 250 h. p.; overhead cond. VAN DEPOELE.

Scranton, Pa.—The People's St. Ry.; overhead. SPRAGUE.

South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; 8 mi. (Enos elevated railway); 40 and 56 lb.; 10 m. c.; track conductors. DAFT.

Springfield, Mo.—2 mi. FISHER.

Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; *G. M.*, H. McGonegal; 4 mi.; g. 4-8½; 8 m. c.; 4 p. c.; steam power; sta. 250 h. p.; overhead cond. THOMSON-HOUSTON.

Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

Notes.

THE BINGHAMTON, N. Y. electric road will soon receive additional electric outfit from the Thomson-Houston Electric Co.

THE SPRAGUE Co. has made a contract to supply electric plant to the Sandusky, O., street railway.

DENVER, COL.—The Short-Nesmith series electric road has been discontinued for some months. It is now being transformed into a cable road.

THE electric road, Richmond, Va., carried 17,108 passengers on the fourth of July last.

THE THOMSON-HOUSTON Co. has taken a contract for constructing a six mile electric road at Wichita, Kan.

THE OTTAWA ELECTRIC STREET RAILWAY Co. has been incorporated with a capital of $100,000.

THE HARTFORD AND WETHERSFIELD HORSE RAILROAD, Hartford, has been granted permission by the city council to use electricity as a motive power.

AT MERIDEN, CONN., the electric street railway is progressing favorably. Manager John L. Billard expects to have three cars running early this month.

BOSTON, MASS.—The Sprague Electric Railway & Motor Co, have closed a very important contract with the West End Railway Co., of Boston, Mass. The present equipment will consist of 12 miles of track and 20 cars, and everything is to be as complete as possible, in all details. Ornamental iron poles will be used.

PROFESSOR SIDNEY H. SHORT, formerly of Denver, Col., now of the firm of Sidney H. Short & Co., Columbus, Ohio, is following up his series system of electric street railways, adapting it to both conduit and overhead conductors. Mr. Short adopts and recommends the Brush dynamo for a generator.

THE HILL CLUTCH WORKS, Cleveland, O., whose clutch pulleys and couplings find favor in electric light stations, issue a very complete catalogue and price-list including plain pulleys, shafting, pillow-blocks, journal boxes, etc., with other information useful to the trade.

THE absurd deadlock that prevents the North and East River company from building its electric road in Fulton street still continues. The Bleecker street company still refuses to allow a short section of its track to be used in common, and nothing can be done without further legislation, the obtaining of which would consume months of delay, and has already been tried for in vain.

.... BARE electric wires could with safety be run through powder in bulk, and a heavy current transmitted, provided the conducting wires were large enough to carry the current and remain cool.—*Electrical Review*, New York.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From July 24 to August 14, 1888 (inclusive).

Alarms and Signals:—*Electrical Call System*, J. C. McLaughlin, 386,597. *Watchman's Electric Time Recorder*, G. F. Bulen, 386,767. *Electric Signal or Alarm*, E. Davis, 386,772, July 24. *Auxiliary Fire-Alarm Apparatus*, W. J. Dudley, 387,585, August 7. *Flash-Light Signal*, W. H. Thompson, 387,932, August 14.

Clocks:—*Electric Clock-Synchronizer*, A. G. Wiseman, 387,276, August 7. *Circuit-Closer for Electric Clocks*, C. D. Warner, 387,703. *Electric Clock System*, C. D. Warner and A. D. Bennett, 387,704. *Electric Clock-Synchronizing System*, C. J. Hexamer, 387,974, August 14.

Conductors, Insulators, Supports and Systems:—*Machine for Covering Wire*, W. H. Sawyer, 386,561, July 24. *Electrical Non-Conductor*, C. T. Lee and C. N. Waite, 386,925. *Electric Insulator Peg*, W. E. Joslin, 386,986, July 31. *Insulation for Mechanical Telephone Conductors*, F. E. Clark, 387,969, August 14.

Distribution:—*Method of Automatic Regulation for Electric Currents*, R. Belfield, 386,797. *System of Electrical Distribution*, M. M. M. Slattery, 386,936. *Regulator for Electric Circuits*, R. Belfield, 386,956. *Electric Converter*, O. B. Shallenberger and H. M. Byllesby, 387,013. *Apparatus for Electrical Conversion and Distribution*, W. Stanley, Jr., 387,117. *Flue for Electric Transformers*, E. Thomson, 387,123, July 31. *Electric Regulator*, J. A. Vansant and F. S. Anderson, 387,463. *Regulator for Electric Currents*, same, 387,464, August 7.

Dynamos and Motors:—*Dynamo and Motor*, C. E. L. Brown, 386,685. *Dynamo-Electric Machine*, W. Fritsche, 386,775, July 24. *Brush-Holder for Electric Machines*, A. Schmid, 387,010. *Regulator for Electric Motors*, A. G. Waterhouse, 387,194 and 387,195, July 31. *Dynamo-Electric Machine and Electric Motor*, R. E. B. Crompton, 387,343. *Armature for Dynamo-Electric Machines*, A. W. Meston, 387,432, August 7. *Electric Motor*, B. A. Fiske, 387,714. *Regulator for Dynamo-Electric Machines*, C. L. Buckingham and H. Lemp, 387,853, August 14.

Galvanic Batteries:—*Porous Cup for Electric Batteries*, B. J. Wheelock, and J. W. Wheelock, 386,569, July 24. *Battery Zinc*, R. L. Carr, 387,049, July 31. *Galvanic Battery*, E. M. Hewett, 387,642 and 387,643. *Jar for Galvanic Batteries*, B. Overlack, 387,654. *Electrolyte for Galvanic Batteries*, D. H. Fitch, 387,679. *Galvanic Battery*, G. T. Woods, 387,839, August 14.

Lamps and Appurtenances:—*Automatic Regulator for Electric Lamps*, R. Belfield, 386,796. *Storm-Protector for Electric Lamps*, T. H. Brady, 387,044, July 31. *System of Combined Arc and Incandescent Electric Lights*, H. P. Brown, 387,615, August 7.

Measurement:—*Inductometer*, G. Miot, 386,648, July 24. *Galvanometer*, P. Lange, 386,992 and 386,993, July 31. *Method of Measuring Electricity*, G. Forbes, 387,505, August 7. *Meter for Alternating Electric Currents*, O. B. Shallenberger, 388,003. *Method of Measuring Alternating Electric Currents*, same, 388,004, August 14.

Medical and Surgical:—*Electro-Medical Apparatus*, J. S. Muir, 386,754, July 24.

Metallurgical:—*Amalgamator*. A. H. Eysaman, 387,347, August 7.

Miscellaneous:—*Electric Valve Controller*, E. Grah, 386,463. *Electric Governor*, H. W. Parsons and J. Hodult, 386,602. *Latch-Opener for Knitting Machines*, L. Jones, Jr., 386,636. *Electrical Type-Writer*, J. F. McLaughlin, 386,646. *Coin-Operated Induction-Coil*, P. G. Williams and A. W. Roovers, re-issue, 10,949, July 24. *Temperature Regulator*, C. W. Johnson, 386,828. *Coin-Operated Induction-Coil*, P. G. Williams and A. W. Roovers, 386,860. *Coin-Operated Electrical Apparatus*, P. Everitt, 386,919. *Lightning Arrester for Electric Circuits*, F. A. Cheney, 387,051. *Electric Indicator*, W. A. Anthony, 387,131. *Galvanic Boiler-Cleaning Compound*, F. J. Clamer, 387,145 and 387,146. *Electric Rock-Drill*, G. Guntz, 387,160, July 31. *Electro-Mechanical Movement*, R. H. Mather, 387,310. *Electric Switch-Lock*, E. L. Orcutt, 387,36 . *Electric Switch*, J. F. McElroy, 387,526, August 7. *Electric Cut-Out*, J. A. Powers, 387,732. *Automatic Coin-Operated Ticket Printing Weighing Scale*, E. E. Amet, 387,842. *Process of Preparing Aluminum Bronze and other Alloys*, P. Heroult, 387,876, August 14.

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THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS.

PUBLISHED MONTHLY AT

11 Wall Street, New York City.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies, -		.30

[*Entered as second class matter at the New York, N. Y., Post Office, April 9, 1888.*]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

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VOL. VII. EXTRA—SEPTEMBER 15, 1888.

PROCEEDINGS OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION AT THE FOURTH SEMI-ANNUAL CONVENTION (EIGHTH MEETING), HELD AT NEW YORK, AUGUST 29, 30 AND 31, 1888.

FIRST DAY'S PROCEEDINGS—WEDNESDAY, AUGUST, 29.

THE convention was called to order at 12 M. at the Hotel Brunswick, on August 29, by the president of the association, Mr. S. A. Duncan, of Pittsburgh, Pa.

The president addressed the convention as follows :—

PRESIDENT'S ADDRESS.

Gentlemen of the National Electric Light Association in convention assembled:—

WHEN this association, after six months of existence, last met in this great city of New York three years ago, but sixty gentlemen were present. To-day we are over three hundred, in other words, the attendance has increased five-fold. I am, therefore, able to congratulate you upon the growth, prosperity and stability of this organization, in whose welfare we are all so deeply interested, and in whose commercial usefulness we all take pride ; for we all had a hand in its making. And I am also able to congratulate you upon that which is more important than numbers, and that is the fact that this association is rapidly becoming the centre of all matters pertaining to the arts which depend on the application of powerful electric currents, and that its proceedings are watched with growing interest not only by the whole electrical public of this country, but also abroad. It is sometimes interesting to notice how we are regarded beyond those limits which properly come within our jurisdiction; and I would call your attention to a fact, which is certainly not uncomplimentary, and it is this :—although during the early days of our history the technical papers abroad paid no further attention to our proceedings than to ridicule them, yet of late, and more noticeably for the last six months, almost every paper which has been read before this association has been copied by the leading electrical papers all over the world. And can there be a better indication of the growth of the industries which have been fostered by this association than the fact that they support in this country no less than eight journals devoted exclusively to electrical matters? This prosperity, upon which we have been mutually congratulating ourselves, has been due not only to the commendable efforts of the rank and file of our membership, but also, in no small degree, to the good judgment, perseverance, untiring energy and marked ability of our honored past-president, Mr. J. F. Morrisson, and the able committees which have assisted him in administering the affairs of the association.

But it is of more importance to us to consider the present state of the industry. From time to time statistics as to the amount of electric light apparatus in use in this country have been presented to the association. At Pittsburgh it was estimated that there were no less than 4,000 isolated plants, and central stations operating 175,000 arc lights and 1,750,000 incandescent lights. To these figures we may now add that there are 1,351 new isolated plants and central stations operating 35,201 arc lights and 392,944 incandescent lights, of which I have a detailed record. By adding this increase to the figures of six months ago, we find there are now 5,351 isolated plants and central stations, and there are burning every night in the year in the United States no less than 192,500 arc lights and 1,925,000 incandescent lights. We may also add that there are 459,495 h. p. of steam engines devoted to electric lighting. Figuring this in coal consumption, it can be demonstrated that, in the year 1888, enough coal will be consumed in the United States for electric lighting purposes to make a solid column one hundred feet square and over a mile high. It may be here parenthetically remarked that there has been an increase in the capitalization of the electric light companies of the United States in the last six months of not less than $42,210,100.

But we have not yet touched upon the great industry of the electrical distribution of power. There are, at the present time thirty-four electric railways (of which I have a record), completed and in operation in the United States, having an aggregate of 138 miles of single track, and operating 223 motor cars and utilizing 4,180 h. p. in stationary engines. There are, also, now in process of construction 49 other electric railways, aggregating 189 miles of single track, which will operate 244 motor cars; thus at the present time there are constructed and being constructed 83 electric railroads aggregating 327 miles of single track and operating 467 motor cars. In this connection it must be remembered that there are 39 other electric railroads incorporated which have not yet begun construction. It is also estimated that the electric cars now in operation in the United States will carry in the year 1888 no less than 17,045,500 passengers. It can be better imagined than estimated what will be the ultimate outcome of an industry which has arrived to such a degree of development in three years.

In view of the difficulty of compiling statistics on such small unities, it has been impossible to collect reliable information relative to the stationary motor business, but we know that at the present time it has stimulated capital to such an extent that there are single factories employing no less than 1,500 hands each in the manufacture of electric motors, and, at no far distant day, all large cities will have their power stations of several thousands of horse-power each, distributing energy throughout every ramification of industry. So rapid a development of this new industry into gigantic commercial proportions should be an admonition to the electric light companies now in the field to reap the harvest which is white to their sickle, and not to wait for competitors to come within their field of operation in the shape of power stations; for power companies, once established, will reach out and take in a large portion of the electric lighting business.

The present meeting of this association gives promise of being one of the most interesting so far held. The report of the secretary and treasurer shows the association to be in a gratifying financial condition, there being a balance

of a thousand dollars in the treasury after the payment of all bills, and the membership is steadily increasing. The proceedings of the last four conventions have been printed and furnished with a thorough cross index, and each member has been provided with a copy. The admirable way in which the proceedings have been printed reflects credit upon the executive committee, under whose direction it has been carried out, and the carefully compiled cross index, and the accurate technical proof reading of the publishers of "Modern Light and Heat" deserve creditable mention. The report of the executive committee, through its chairman, Dr. Otto A. Moses, and the reports of the several committees, together with the papers to follow, should command the closest attention of the entire convention.

The difficulty of obtaining reliable statistical information in regard to the various electrical industries, and thus keeping up a continuity in the work of the association from one convention to another, warrants the president in urging upon the association the necessity of establishing a permanent office which shall be a repository of all information relative to the allied electrical industries, and a means of intercommunication between its members, and from which the officers and executive committee can administer the affairs of the association. This office should contain a good reference library of electrical works, complete files of all domestic and foreign electrical and other technical journals, and be the repository of the archives of the association. It should be a place where every member of the association could feel at home, and where he would naturally go for any electrical or other information that it contained. A very slight increase in the running expenses of the association would maintain such an office, and when established it would, from its innate value, increase the membership of the association to such an extent that the running expenses of such an office would take care of themselves.

Does not this association, having, during its years of growth, spread its roots widely through the electrical industry of this country, stand upon the eve of becoming much more widely influential than ever before by carrying out the suggestion of Mr. Frank Ridlon, at the convention in this city three years ago, which was further elaborated by a committee specially appointed for that purpose, which reported, through its chairman, Dr. Otto A. Moses, at the Detroit convention, and was still further advocated by Mr. Arthur Steuart, Mr. E. R. Weeks, Mr. A. J. DeCamp, at subsequent conventions—namely, the establishment of a permanent headquarters as already sketched out?

Gentlemen, in conclusion, I will say that in no way can you better assist the chair in the discharge of his duties, and in no way can you aid in making this convention a thoroughly successful one, than by a constant attendance at its sessions. I know that the more than generous hospitality in the shape of various entertainments, as mapped out by our New York friends, may tend somewhat to distract your minds from the serious business for which you have assembled, but I also know that you can find ample time, not only to accept of their hospitality, but to give to this convention your entire time and attention during its sessions.

Gentlemen, it affords me great pleasure to have with us this morning a gentleman of national reputation, with whose name you are all familiar. I have the honor of introducing the Hon. Abram S. Hewitt, Mayor of the City of New York. (Applause.)

His Honor, the mayor, then addressed the convention :—

ADDRESS BY HON. ABRAM S. HEWITT, MAYOR OF NEW YORK.

Mr. President and Gentlemen of the Convention:—

My duty on this occasion is as easy as it is agreeable. I am here to bid you welcome to the City of New York, and to tender you such hospitality as the mayor of this city has it in his power to offer. To distinguish strangers, I think the usual form is to give the Freedom of the City in a Gold Box. If you will leave out the Gold Box I can tender you the Freedom of the City, but exactly what it is I do not know. (Laughter.) But to those who are strangers here I trust it will be found exceedingly pleasant and highly profitable.

I gather from the remarks of your president that you are here to take an account of stock of what you know about electrical science and its application to useful purposes. I think it will be easier for you to ascertain how much you do not know than to find out how much you do know about this subject. (Laughter and applause.) And in the last part of that inquiry I am in entire sympathy with you. When I have confessed, as I have had to do on various occasions, that I did not know anything about this subject, it has been received with incredulity, but you who do know something about it know that I am exactly right. When you reflect upon what you have to do you must be rather appalled at the magnitude of the contract. This convention must strike the average uninstructed mind pretty much as a meeting of astrologers in the ante-Christian era would have done throughout the orient, or a convention of necromancers and magicians during the Middle Ages. You deal with something very mysterious to the popular mind, almost incredible. You have already performed wonders which even to the most intelligent men can only be regarded as miraculous. You stand to-day pretty nearly in the condition in which Watt, 110 years ago, must have found himself when he produced the first perfected condensing engine. Crude forms of engines had been in use doing more or less effective work prior to his day; but in 1776, the year of our emancipation from foreign control, Watt produced the first real working machine. Now, what has been done in 110 years. Could any man if he had been gifted with the power of prophecy—could any man have foreseen the transformation which the whole world would undergo in a century from the time of that great invention? Can you conceive of the world without a steam engine? Could the population which now inhabits the globe survive for 60 days if the steam engine were withdrawn from use? Would civilization continue in existence to-day without the steam engine? Now, gentlemen, looking back you can see how the application of one great motive force can transform the face of the world. Looking forward, is there a man here who can tell us what this new electrical force is going to do for the world? Can any man say how it is to be enriched, how it is to be purified, how it is to be exalted from the depths of poverty and suffering into which in large part it is plunged? If electricity, like air and water, could be made free to the hand of labor or to the wants of men, could be on tap, so to speak, either without charge or at a merely nominal cost, do you not see that all monopoly would cease to exist? For monopoly consists in nothing but the power to appropriate force to personal and private use. If all force and all power were made free to all men, is it not apparent that the inequalities of fortune and almost all the evils of which mankind complain would disappear? Is there anything more astonishing in this prospect than in the retrospect, which you can all take, of the work that has followed the introduction of the steam engine? I used to be told when I was at school—I don't know how it is now—that the earth is a great magnet. You may have changed all that, but I hope you have not for I do not want to lose what little I do know. (Laughter.) We used to be told it was a great magnet, and that it revolved on its axis once in 24 hours, and that it was 25,000 miles in circumference. Now, that strikes me as the definition of a mighty large dynamo. If a great magnet 25,000 miles in circumference is put in revolution so as to turn on its axis once in 24 hours, from what I have seen of the dynamo it strikes me that there must be a vast incalculable fund of electricity produced by that operation. (Applause.) I know nothing about it, I may be talking nonsense; but at the same time, if that be true, and if it be true of the whole planetary system, and

of the whole universe of the Divine Architect, what a vast fund of unappropriated power there is for mankind in the future; and knowledge is power and power is wealth, and wealth, which is free to all who have the brains to take it, is the benefaction of mankind and the opening of the gates of the millenium, if we are ever to see it, it will be accomplished by you gentlemen and those who will come after you, for this is the only course that I am able to see by which the goodness of God, the bounties of Divine Providence can be distributed with a free hand to all the world, and to every man, woman and child within its bounds. (Applause.)

Upon the borders of this land of dreams we stand. You are slowly raising the curtain of the future. I shall not see the drama played to the end; but there are men in this room who will live to see society transformed by this new agency; for it is a curious and suggestive fact that all moral forces and all moral questions find their final resolution in the facts and laws of physical nature. There is where you come at last. If this world is a better world to-day, a richer, a happier, a more enlightened world to-day than it was a hundred years ago, it is due mostly to the steam engine and its applications. If it is to be, as I believe it is to be, a better world, year by year and century by century, it will be due to the discoveries and applications of electrical force, or of some other force which possibly may be hereafter discovered and developed; but to-day we must call it by the name which you and I know it by—the electrical force.

Hence I bid you welcome to New York. I am glad to see you. You are benefactors. You come to two millions of people with a gospel. You are the apostles of a new industrial dispensation. You are distributors of this overgrown wealth which you hear is in few hands in this great city. It cannot stand your attacks. It has withstood the preacher and the moralist and the philosopher; but it will not stand against the scientist who discovers the laws of nature and who makes them free to all who will drink at the fountain of science. (Applause.) Yes, you will revolutionize the world; you will regenerate society; and it is none the less to your credit that while you are doing it you are making your living and getting an honest compensation for your labor; for it is a law of Divine Providence that utility and beneficence shall march hand in hand down the highways of civilization. They are bound together by a divine law, and you are the executors of that law when you open new fields of discovery, and new applications of force to useful purposes. Of course we bid you welcome, and we bid you welcome because we feel that we are so ignorant and need your help. We are engaged in this city in undertakings which require from you your honest and best judgment. We send messages by wire through our streets. We light them through conductors perched upon poles. We talk through a network of wires so thick overhead that often the sky is obscured. They are not pleasant to look at, but they are indispensable, in the present state of knowledge, to the business of society. (Applause.) The man who would disturb them until something better is found out and proved to be found out, would be a barbarian. (Applause.) Still, like the mayor, they have got to go. (Laughter.) But the mayor is too old to go at a 2.40 gait, and he likes to see his way clear before he takes a step. Now, in order to clear up this matter a little for you who know so little, as I have said, about this subject, and I, knowing so much, let me say that this much seems to have been found out at some cost to somebody. I do not know who—that it is quite feasible to put underground all the telephonic and telegraphic wires, and in fact all wires which carry low tension currents. I suppose that is now demonstrated, and I trust that in a very short time this city will be relieved from the unsightly telegraphic wires, telephonic conductors and from any modes of diffusion for the incandescent lighting which may still remain above ground. I suppose that is all feasible. The question what to do with the high tension currents remains. First, we ask you to tell us—at least I ask you to tell me, because there are some people here who know better than I do—whether a satisfactory mode of cable transmission for high tension currents underground has yet been devised. I understand that a cable for the Brush company is about to be laid in one of the conduits which have been constructed in Broadway, and I suppose that will test the question as to the feasibility of the transmission of high tension currents practically and economically, because there is no sense, you know, in things that don't pay; if it is too dear we have got to give it up. (Applause.) I suppose that that will test the question, and I am very glad of it. I have been censured—possibly by you electrical gentlemen; I do not know—very much, for not having taken steps to coerce all these lighting companies into putting cables underground until that question was settled.

Well, I am no longer a young man. I have had a long experience in life. I have done a pretty large business in my time. I have had to deal with very difficult problems, and I have learned that the part of wisdom is to go slowly and to ascertain your facts and get your knowledge before you undertake to reconstruct the universe. I have been very desirous that this matter should be tested —this question of transmission of high tension current underground—at the earliest possible moment, and I congratulate you on the fact that it is going to be tested by a responsible company, and until it is tested, let me say to you frankly that if it were in my power to compel the other companies to do this thing now to-day, I would not do it. (Applause.) I should look upon myself as an everlasting fool who ought to be consigned to seclusion in a madhouse if I did such a thing. But I hope it will succeed, and if it does succeed no public officer will be more prompt than I shall be in compelling every electric light company to respect the intention of the legislature when it confided this great work to four men who did not know anything about what they were going to do. (Applause.) The legislature evidently recognized the fact, which you recognize and I do, that what we don't know about electricity is a good deal more than what we do know about it, and so, as they could not find men who knew about electricity, they *did* find some men who were supposed to understand politics if they did not know anything else. I speak thus frankly, because I am one of the four men. (Laughter and applause.) I should be the last man to cast any imputations upon my colleagues who have charge of this most interesting and important public work; but I think that we shall all of us be wiser—my colleagues as well as myself—after a little more experience has been gained.

Now the second question is this: When the cable is underground and works successfully, will you kindly inform me and the public, in whose behalf I address you, whether a satisfactory system of distribution from the conduits has been discovered and put in practice? It is one thing to put the current underground and another thing to get it out so that there may be lights. Now, I know nothing about it; I have simply made inquiries of every intelligent electrician that I could meet, and up to this time I have not been able to ascertain that there is a satisfactory mode of distribution. Now you know whether there is or not. If you should say to me, after a discussion of the subject that there is, I should accept your judgment as final, because you embody all that there is known of this difficult subject, and if you, by your resolution, say that there is a proper and comprehensive system of distribution so that the evils that are complained of will be abated and that there will be absolute safety in the distribution, then my mouth will be closed, and I shall act upon your judgment; and that is the reason why I have come here, chiefly to-day, not simply to welcome you as strangers and guests from abroad, but to ask you to consider this subject coolly, dispassionately, intelligently, and give us the results of

your discussion, so that we may act coolly, dispassionately and intelligently in carrying out the law.

Now as to the matter of danger. The newspapers have teemed during the last year with sensational articles pointing out the great danger of the present system. Remember I do not like the present system. I regard it as—I was going to say—barbarous. The streets should not be defaced. We should not have these wires running about. But let us get at it on proper grounds—æsthetic grounds, if you will, scientific grounds, economical grounds—any other grounds than prejudice and sensation. Those I take no stock in, and I will never allow myself, and I trust no man who is a lover of truth will allow himself to be dragooned by the newspapers into doing what he believes to be wrong. Now, is this dangerous, will you kindly tell us? I thought it was exceedingly dangerous; I went into office with the impression that every man who went out in a street lighted by a high tension current took his life in his hands, and I was as anxious as anybody to get the wires removed; but when it became my duty to look into the matter, I found that in proportion to the amount of work done, measured by our friend the president's column of coal, if you like, or by those other things that you call ohms and volts, and which my colleagues of the board of electrical control are flinging at the common council pretty much as that distinguished millionaire at Saratoga turned out his gems among the boys the other day—(laughter)—I found, measuring this industrial element, call it what you like—some name you must call it—this force, this power, measuring it by the work it was doing, and ascertaining the accidents that occurred, to my astonishment I found that we had more accidents daily from the horses in the streets—infinitely more; that we had more accidents with steam engines; that even the building of houses in the city caused more deaths every year—infinitely more deaths in this city than this particular agency. I was therefore driven to the conclusion that considering the work it was doing, comparing it, if you like with the illumination by gas, that it was positively safer, just as the railway had proved to be safer than the stage coach and the stage coach probably safer than walking, for the number of people carried. I found that with all the difficulties with this thing, the absolute results seemed to show that it was absolutely safer than any other useful agency at work in this city. That was the conclusion to which I was forced. But then, when I investigated the cause of the accidents, I discovered that they were not due to anything that was inherent in the transmission of the current overhead; but they were rather due to two causes—either the carelessness of the company in inspecting its installation, and keeping it in good order, or in the carelessness of the person who came in contact with it—one or the other. Now there is no excuse for the company, not the slightest. They undertake to render a public benefit; they are paid for it; they undoubtedly ought to see that their plant is in the most perfect order possible, and any company that neglects to keep its plant in proper order is, of course, liable to the penalties of the law, and I would be the first to have the officers of such a company indicted, if I could. But I take it that the duty has been on the whole pretty well performed, because the accidents have been so few. They have been very few indeed. I believe that in this city there are but four cases of death in consequence of any difficulties with the wires themselves. I may be in error. It is either four or seven, but I believe it is four. Now, under the circumstances, the thing that would seem to be wanted—and I think it will be wanted when you come to your plan of distribution just as much as it is wanted now—is a thorough inspection of the means by which the light is made available to the public above the ground, and that inspection should in the first place be made by the companies themselves, who have the greatest interest in the matter and the largest duty to perform, and I fully agree that the public, who have a great interest in it, should also have a thorough inspection, and the reasonable rules and regulations which may be adopted by the body that is charged with the custody of this matter should be implicitly obeyed, and any violation of them ought to be severely punished. But I would like you to consider the whole question, not merely the distribution; but if you come to the conclusion that no adequate mode of distribution has been found which will dispense with the present mode, then, that you will consider and advise us how we can make it safer to the public, and thereby more economical and useful to the companies who supply the lights. These are questions of such paramount interest in this city that your presence here is most welcome. I trust you will give us the benefit of your knowledge, and when you do not know I hope you will say so and confess your ignorance like men, for that is what I have now been doing, and what I intend to do so long as I am mayor. Gentlemen, you are welcome to New York. (Applause.)

The President—Your Honor: in accepting on behalf of the association the freedom of the City of New York, I desire to confess that, like yourself, I do not know what it is, but I may state to your Honor that in whatever city we have been the association have practically taken control of the city for the time they have been in it.

In regard to the considerationof the points brought forward by his Honor in his address I desire to say that this whole question will be considered to-morrow morning at 10 o'clock, when we shall be very glad to have his Honor present with us. We have already extended an invitation to the members of the subway commission and others who are interested in this matter, and we are seeking for all the light we can obtain on this subject. We have come to consider this matter calmly, coolly and dispassionately, not only for the interest of the public at large, but for the interests of the electric lighting companies, and I can assure you, sir, that we will consider the subject in the spirit which you have suggested.

I now declare this convention open for the transaction of such business as may be brought before us.

The first business in order is the report of the secretary and treasurer.

Mr. W. H. Harding, secretary and treasurer, then read his reports. The secretary's report showed a membership of 189, over three times the number of original members.

Mr. Harding's report as treasurer was as follows:—

TREASURER'S REPORT.

BALTIMORE, August 25, 1888.

Report of the Treasurer of the National Electric Light Association.

Feb. 18, 1888.	To Balance....................	$ 971.67
	Dues received from February 19, to Aug. 25....................	1,480.00
	Contributed from Westinghouse companies at Pittsburgh......	1,150.00
	Contribution from Chas. Schieren, N. Y........................	50.00
		$3,651.67
	Disbursements.	
	As per detailed report..........	1,716.44
		$1,935.23

The reports of the secretary and treasurer were received, and ordered to be filed and printed.

The secretary read a letter from Mr. George Worthington, Editor of the *Electrical Review*, inviting the members of the association to visit the "Fall of Rome," at Staten Island in the evening; an invitation from Mr. Theodore Moss to attend a performance at the Star theatre, an invitation from the Okonite Company to attend a performance at the New Broadway theatre Thursday evening, and an invitation from the Electric Club to all the members to visit the club house during their stay in the city.

On motion of Mr. C. A. Brown, of Chicago, it was voted that a committee of five be appointed by the chair to select the place for the next meeting of the association and to report to this convention.

The President—We will proceed with the order of business, and take up the report of the committee on the testimonial to Mr. J. Frank Morrison, of which Mr. T. C. Martin is the chairman.

Mr. T. C. Martin—Mr. President and gentlemen: in accordance with the resolution adopted at the Pittsburgh meeting, the resolutions there passed with regard to the services of Mr. J. Frank Morrison to the association have been engrossed. I have the resolutions in my hand and I believe that it would be in keeping with the wish of the meeting if before the presentation of the engrossed resolutions, they be read. They are as follows:—

"*Whereas*, it has pleased Mr. J. Frank S. Morrison to insist upon

not being re-elected to the position of president of the National Electric Light Association, which he has continuously held since its organization; and whereas, we have tacitly agreed at our successive re-elections of him to allow him to retire (as he has invariably requested at each meeting) whenever the interests of the association would not suffer by such action; therefore, be it

"*Resolved*, That we, the National Electric Light Association of America, representing in our midst every department of electric light and power industry, express our deep regret at the decision of Mr. Morrison not to allow us to keep him at the helm, where, through many storms and quicksands, through much fair weather and some foul, he has successfully guided us to the haven where we now find ourselves; and be it further

"*Resolved*, That a vote of thanks be given Mr. Morrison for the disinterested devotion, enthusiasm and steadiness with which he has administered the affairs and presided over the proceedings of our conventions; and that, further, we tender him our best wishes for his deserved enjoyment through a long and prosperous life, of the beautiful prospect of the great work he has done in founding, fostering and chartering the National Electric Light Association."

Such, Mr. Chairman, were the resolutions, and there (presenting the engrossed and bound resolutions) is the result of our work. Mr. Morrison, I have the greatest pleasure, in the name of the association, in tendering you the engrossed resolutions which have just been read. (Applause.)

Mr. Morrison—This is perhaps the first occasion since my acquaintance—my intimate acquaintance—with the gentlemen who compose the National Electric Light Association when I have been glad that I am not very well. I find, at this very agreeable surprise party which you have prepared for me—and it is a wonder it has been kept quiet when so many men knew it—that I am almost unable to talk, and you know what a terrible thing that is to me. I accept the gift which you have presented, and I think it is needless for me to say to you, and I think you will believe me when I say, that I fully appreciate the spirit in which it is tendered. At the start this association required, perhaps, different material in its presiding officer from that which it requires to-day. I believe that for the first year I filled the bill fairly well. I do not flatter myself very much. I believe that after the first year a man more yielding and conciliatory than I am would perhaps have filled the bill better. Through your kindness and indulgence I was continued in that honorable office until last February, when you kindly permitted me to retire. For that and the beautifully engrossed resolutions expressed in such kindly terms I now thank you. I am not out of the service by any means. I hold the honorable position of a member of the executive committee, and I do not propose to be a deadhead in that or any other part of this enterprise. I am at your service now, gentlemen, as I was before, and I expect to remain in the service so long as the National Electric Light Association exists and I live. I thank you for the compliment. (Applause.)

The president then called for the report of the executive committee. The chairman, Dr. Otto A. Moses, reported verbally, as follows:—

REPORT OF THE EXECUTIVE COMMITTEE.

At a meeting this morning of the executive committee, preparatory to the beginning of our exercises, I announced that owing to the pressure of circumstances and the numerous arrangements that had to be made, I had not been able to prepare a report of the executive committee. A gentleman who has just left here said that sometimes in weakness there may be strength, meaning by that that having no report to make perhaps I might get over it quicker than I might otherwise do. The facts are, we have been doing as Doctor Arnold did when he said "A teacher is a man who is striving all the time to make himself useless." The executive committee of this association has striven so far to become a vanishing point, a zero at this moment, and now the convention has taken the matter into its own hands and the executive committee has disappeared below the surface Our only function was that which is generally given to executive committees, to arrange matters, to bring them into some kind of shape, and chance has a great deal to do with the forming of that shape. Gentlemen, the executive committee has no report to make beyond this, that they deem themselves exceedingly fortunate that the turn of events has allowed the mayor of the city to-day to open up so beautiful a field as he has done. Our business largely shapes itself, and the discussion that will take place to-morrow will be one of great local importance here, and will give zest, I hope, to the entertainments that you will receive of both an intellectual and a physical character.

The report of the committee on revision of the constitution of the association, was then presented by Mr. A. F. Mason, chairman, and was read by the secretary.

Printed copies of the report, ordered by the committee, not having yet come to hand for use of the members in considering amendments, it was voted to defer action on the report till Thursday, making it the first order of business for the afternoon session. [See proceedings and constitution as amended in Thursday afternoon's proceedings.]

The president then called for the report of the committee on insulation and installation of plants.

REPORT OF COMMITTEE ON INSULATION AND INSTALLATION.

Dr. Moses—Gentlemen, I appear here on behalf of the chairman of the committee on insulation and installation, Professor Elihu Thomson being the chairman. I received the following letter from him which causes me to speak for him:—

Lynn, Mass., Aug. 25, 1888.

DR. OTTO A. MOSES,
Hotel Brunswick, New York.

Dear Sir:—It will be impossible for me to make any formal report of the work done by the committee on insulation and installation of plant.

If you will prepare a brief statement of what was done at the meeting and attach the enclosed schedule of data to be asked for, I think that it will be all that can be done under the circumstances. This might be presented as an informal statement of what was being undertaken by the committee, and the association might then be called upon for the preparation or printing of a number of such blank schedules to be sent to the various electric light companies.

The spacing in the schedule will need to be modified so as to give more room in some places and less in others for the answers to the questions.

I am hoping to be able to run down to the meeting, but I may not be there at the time when the report may be in order, and will therefore look to you, if present, to say what you can of the progress made.

Some time ago I sent a copy of the schedule to each member of the committee, but have thus far received but two acknowledgements. Yours truly, ELIHU THOMSON.

Gentlemen, I stood last year in the position of apologizing for the action of this committee, and it was a most unfortunate position that I was put in, because I had been somewhat instrumental in organizing it. Everybody, however, was so much occupied with the rush and push of these matters that it was impossible to get what ought to have been obtained with the amount of talent that I was able to suggest should be put upon that committee. I was put upon it involuntarily, gentlemen. However, the committee has met, it has done work, and here you will find it embodied in a series of questions. But like a great deal of work that is contained in a very small space you will find that it does not show to any very great advantage. This schedule referred to here is for the purpose of obtaining data on the insulation of wires. There are 99 questions in it. Gentlemen, I would say there were a hundred, but you know the old story. There are just 99 questions and they will all be submitted to you in due time. I hope that you will all reply to them very carefully so as to give us data or our successors data to produce some valuable information for this association. These questions go to the very root of the life, use, advisability of employing conductors of all kinds. It is divided into various heads, and if you will only each of you write a small book—because to answer these questions means to write a small book to this association, we will have a library of our own that will come out of the actual experience of the members of this association. None of the members of the committee have written papers on the subject. We have had several meetings. These questions are the result of conference on the subject. However, to-morrow on the occasion of the underground discussion you will hear a very important paper read by the only member of the committee who did not feel himself justified in serving—that was Mr. Acheson, of Pittsburgh. It was the only compliment he was able to return to the association for the honor they had done him in electing him a member of the committee, although he was an interested party. It was a high compliment, and he shows his appreciation of it by reading a paper on the disruptive discharge in underground currents. It was hoped by the president in appointing this committee that each member would take a branch in a scientific direction in the solution of this question. Mr. Acheson has set a good example. I must admit that I tried to have the committee take that general direction, but failed of success from want of leisure which brings many a man to do things that he would not otherwise do, because they were all disposed to write scientific articles, but they were compelled to embody as much as they could in these questions throwing on you the onus of answering what you would answer.

That is the report I would offer for the chairman who is absent. He may come in the course of the day after I have received the brunt of all your criticisms. But I must say it is not my fault; I must say that in self-justification. So far as your position in this matter is concerned, all you have to do is to appoint another committee, if it is thought desirable to continue the subject, and step by step to gather such information as can be obtained by answering these questions. It will take a great deal of labor to collate the information which will be gained when this paper is distributed through the whole country.

Dr. Moses read the schedule submitted by the committee, which is as follows:

DATA ON INSULATION OF WIRES.

Name of company.
Location.
Name of superintendent or person having charge of lines and machinery.
How long has he been in charge?
Character of plant. Arc? Incandescent?
Systems in use. Dynamos. Lamps.
How long is line (miles or feet).
What wire or wires have you used and found unsatisfactory?
For what purpose used, and the defects found.
Do you use extra insulation on portions of wire exposed to moisture or abrasion?
If several kinds of wire are used please fill out enclosed blanks, one for each kind of wire.

OVERHEAD WIRES

Name of wire.
Maker's name and location.
When purchased?
How long in use by you?
Material of wire (copper)?
Diameter of metal, or gauge number (B. & S.).
Diameter over covering.
Weight to the mile.
Stranded or solid wire, *i. e.* flexible cable of a number of wires or not?
Furnish, if possible, a small sample, say five inches, and send by mail with a tag attached.
How supported?
What kind of insulators?
If more than one kind please state specifically
Condition of installation with respect too ther wires, as telephone, telegraph and other electric light wires.
Are crosses liable to happen from such other wire?
Condition as to running through trees, etc.
Are grounds liable to happen from this cause?
In arc wiring please say whether all or a part only of the lines are exposed to crosses and grounds.
Are the lines, pole lines or housetop lines, or both?
Have you had trouble from abrasion, or loss of covering from any cause?
At what point between poles is deterioration most likely to occur?
Prevailing or average climatic condition in your locality as to heat or cold, moisture or dryness, etc.
Add other conditions, such as exposure to deposits of soot, exposure to steam or other vapors.
Character of current, alternating or continuous?
Potential of lines.
How many lamps in series (if arc) and what type?
If incandescent wire, what voltage between mains?
If mixed incandescent and arc on this wire, state what capacity dynamo is used on line.
Have you had many leaks by grounds or crosses on this particular wire?
To what cause do you attribute them?
What is your experience with this wire generally? Here state how you regard it as a covered wire, good or the reverse, with whatever remarks you wish to make.
How much of it have you in use?
Are you installing with this wire new extensions of your lines?

INSIDE WIRING.

Name of wire.
Maker's name.
When purchased?
How long in use?
Material, copper.
Range of diameters or gauge (B. & S.).
Heavy or light covering?
Flexible cable or solid wire?
Furnish specimens, say five inches long, carefully tag same, and send by mail.
How supported? cleats, porcelain knobs, moulding, pipe, etc.
Concealed or not?
If a variety, name them.
Character of buildings wired with this particular wire; stores, manufactories, dwellings, etc.
Is any such wiring exposed to damp acid fumes or extreme heat?
Current used, alternating or continuous?
If arc wire, how many and what kind of lamps in series, or what capacity of dynamo?
If incandescent wire, what potential or voltage on lamps or between mains?
If mixed incandescent and arc, please describe the manner of use.
How has the wire stood in use, any faults developed?
Is it fire-proof in your estimation in the sense that it will not carry fire as a wick?
What is your experience and estimate of this wire generally, with whatever remarks are pertinent to it?
How much of this wire have you in use?

UNDERGROUND WIRE.

Name of wire
Maker's name and location.
When purchased?
How long in use by you
Material, copper?
Diameter of metal or gauge (B. & S.).
Diameter of covering.
Armored, lead, covered or not?
Compound or single wire cable, one or more wires in sheath.
Furnish, if possible, a small sample, say five inches, send by mail with tag attached.
How placed and supported, what kind or kinds of conduit, if any, are used?
Are other wires laid alongside either in the same conduit, or parallel in the same soil?
State the character of the soil surrounding the conduit or wires, wet, moist or dry.
How are lateral connections made from the conduits or wires to buildings?
Is there any exposure to escapes of gas as sewer gas or illuminating gas?
If lead covered, does the lead show in any place progressive corrosion?
What are the faults found in your underground wires?
To what cause or causes do you attribute such faults?
Are your underground wires used for arc light works or series work with high potentials?
Are they used with incandescent direct currents and low potentials? or for power lines?
Are such wires used by you with alternating currents of high potential, as in primary lines for transformers?
Compare your experience with underground wires used for arc light work, with that with such wires used for direct low potential; and also with such wires as used to convey high potential alternating currents.
Have you any cable lines under rivers or water?
If so, what satisfaction do they give for arc work or other work?
What is the nature of the faults, if any, which have occurred?
How long has such cable been in service, and what is its character?
State in general the result of your experience with underground wires for the various work.
Are your underground wires connected with stretches of overhead wire?
Are thunderstorms frequent in your locality?
What provision do you make to protect the underground wires or cables from induction or high potentials during thunderstorms?
If such provisions be made, is it effective?
Can you furnish any samples of defective sections of underground wire containing faults, with a statement of the conditions of use?

Mr. E. R. Weeks, Kansas City, moved that the report be received and filed, and the committee continued.

Mr. Morris, Nashville, Tenn.—Mr. President, knowing that a paper on the insulation of wires was to be read was one consideration which led me to come here, so as to learn something about that. My company has under consideration the re-insulating of its entire system, and we do not know what is the best. It seems to me that to determine a good insulation is largely the solution of the underground question; and I must confess my very great disappointment with the report of the committee on that subject. I appreciate the delicacy of the committee's task in reporting this wire or that wire—this manufacturer's wire or that manufacturer's wire; but at the same time it is a question that ought to be taken hold of, and there ought to be some answer to our question. I think if these questions were printed and sent out the answers that you would get would be so small in number that they would practically be of no benefit in arriving at any proper conclusion. I am satisfied that the managers of stations are not going to take the trouble to answer those questions, and practically you will have accomplished nothing. We can only receive the report and discharge the committee and appoint a new one, or continue them. But I cannot refrain from expressing my disappointment in regard to that report.

Dr. Moses—Mr. President, there is a large steam hammer at Essen that strikes a hundred ton blow. It is about twenty feet high, but the foundations of that are two hundred feet under the ground. Now although this report consists of but a few lines there has been an immense amount of thought and discussion between us as to how to arrive at a solution of the question—that is, to make a report on insulation and installation that would be really of advantage to the association. I wanted to have specimens of every conductor that was in use laid before this committee, and to have them make all the scientific tests, and to supplement those with all the practical tests that they could possibly devise. For that reason the president selected a committee

of gentlemen, who had every facility in this country for doing the work. They were not prejudiced by association with any particular manufacturing interests, and each had a very excellent laboratory at his service. The Western Union Telegraph Co. was represented, the Bell Telephone Co. was represented on that committee, so to say; that is, their electricians were selected as proper persons. There were other companies represented, and it was thought that the results could be made very valuable in that way. We had Cornell University present by its representative. They were all willing to do a certain amount of work, they said, but they were all determined that they did not want to appear to be advertising anybody's wire. As much as to say that if the sun shone to-day and they were to praise it they were advertising the one who made it. It was true that that was all they were called upon to do—to report on what was good wire. I tried to carry that through, but they were all too modest and fearful of the results. They then tried to throw this matter back on the association, and get what information they could right through them. Mr. Morris may perhaps be mistaken in supposing that the superintendents of the different companies will be unwilling to furnish this information. I happened to be present last evening at a dinner given in honor of the executive committee of this association, and there was one gentleman who is, I believe, present now, who said, "I waive the executive committee part of it; I speak as the superintendent of a station." Now why cannot we get from every man here who represents a company some information that will be of value to this association. They are plain questions; all we want is that they should be truthfully answered, and the committee will winnow out all the chaff from it, and get at some of those jewels that might be thrown broadcast, such as the mayor spoke of.

Mr. J. F. Morrison—It strikes me the original intention was to find out—that is among the laymen—to find out from the scientists, who are members of the association, what is the best material and how it is best to apply that material to bring about the best condition of insulation for air lines mainly. I do not believe any steps have been taken in that direction by any of the committees that have been appointed. The list of questions which Dr. Moses has just read goes to show that they are on the hunt for the same kind of information we are after. We sought to get the information from them. They are coming back now to get that information from the station superintendents. I do not believe you will get that information there. I do not believe that you will get a foundation that will go far enough into the earth to prevent jarring, if you seek to build your foundation in that direction. I do believe that if the chairman of the committee on insulation were to press the case, month by month, during the recess between the meetings of the association, that he would get from the men, the use of whose laboratories we had in view when the committee was appointed, satisfactory data from practical experiments—from experiments made in lines which the superintendents of companies have not been able to reach, and such information as would put us on the right track in all future operations.

The question of how to steer clear of insulated wire seems to be the one most largely in the minds of the men who own the stock in electric light companies. I beg to call the attention of the gentlemen here who belong to the various companies throughout the United States to this statement which I have just made, and to ask them if there are any here who will fail to corroborate it. If the manager of an electric light company selects a first-class insulated wire for his company, the first question is "What will it cost?" He will state to them that it will cost so much. Why, the answer is, there is Mr. DeCamp's company in Philadelphia that buys wire for twenty-five cents a pound. The president, or one of the directors of your company will say, "Why can't you use exactly the same wire?" Well, you can; but you won't have insulated wire; you will have underwriter's wire; you will have cotton insulation which means no insulation. Now I claim that there are to-day half-a-dozen insulated wires which quite nearly fill the bill that we require. But the moment you suggest any one of those then there arises in the mind of every member of the association the fact that you are boosting some man's business at the expense of some other man's business. The next thing is that you are sat upon. Now one of the evils for which I have never been able to suggest a remedy is just this one. You want information. From whom can you get reliable information? From the man who has followed such a course of investigation as enables him to come with something in his hand and say, "Here is an article which will do so and so." The wire man has produced some sort of an insulated wire, and he makes a broad claim for that wire. Now it seems to me that if this committee was to take the wires offered by the gentlemen who claim such and such qualities of insulation, and apply the apparatus and the facilities which their laboratories afford for the testing of that insulation, and give a fearless and unbiased report, such an investigation I believe will very nearly carry out the idea which was in mind when this committee was first appointed. I throw out this suggestion for the chairman of the committee.

Let me repeat what I have said:—If instead of the committee which has been appointed going to the superintendents of stations and asking them for the information which this association has sought—if they will take the facilities which they possess, and will take the material which is now upon the market—the insulated wires for which such claims are being made—and will make practical working tests of those wires, and will give us the result of that, it will be more satisfactory and more in the line of what was intended when the committee was appointed. There is some sort of a substance that is an insulator. There are a number of dielectrics. There are lines for arc lighting underground and in operation. There are cable lines in the air where wires are all bunched together insulated from each other, and they are in successful operation. Every one knows that incandescent light wire is underground, and that a satisfactory insulation has been found for that. Now, then, among the multitude of able men who have turned their attention in this direction, backed up by enormous capital, why cannot we get at some of the practical results which they have achieved? Stop theorizing. Do not let us attempt to build up a theory, but let us get at the practical facts which these men have reached through this laborious and expensive method, which we all know experimenting to be. I make this suggestion for the benefit of myself and the other gentlemen who desire to know what is best to do in the way of insulation. If Mr. Mason gets up—and I see he is moving in his chair—they will say "That is Simplex;" if Mr. Candee gets up, they will say, "that is Okonite;" if Mr. Hotchkiss gets up they will say, "that is Kerite," and they will go through all the "ites," until your head swims and you get no information. They will condemn this man and say he is getting up to advocate his own goods. I am not adverse to that myself, and I think the sooner you break down that idea and devote a part of your sessions to the purpose of getting information, from the only source where you can get it—from the men and companies who have spent their money in this direction, until you abandon this fool notion that you are boosting one man at the expense of another, just so long you will be groping in the dark, and have such a report as that presented by the committee, with blanks for some superintendent of an electric lighting station to fill in with information about something he knows nothing about.

Mr. A. F. Mason—I do not propose to be held back from speaking on this motion by any fear that any one will say I tried to boom a wire. I do not believe there is a representative of any company who would degrade himself, and abuse the privileges of this floor, by any such course, and I do not believe anybody here will suspect me of any such intent. The president will remember that the original motion made two years ago for the appointment of a committee on insulation I had the honor to propose, and since that time I have felt moved to press the continuance of the committee, or the appointment of new committees. So far the work has not been satisfactory, as the gentleman who presented this *quasi* report to-day has stated. The results have been *nil* so far. Personally I do not believe that all the laboratory experiments that these learned gentlemen and this committee could have made, would have been worth one farthing to the members of this association. I do not believe that laboratory experiments upon insulation give us any reliable practical facts. Furthermore, in talking with gentlemen who are of very high standing as experimenters, I learn that such is their opinion. They allow that they cannot make a series of experiments, one exactly duplicating another. So much for that. I think I may say that I fully agree with Mr. Morris in his opinion that we should get but very few answers to those questions if he sent them out, and if we got them, what is the value of each series of answers? First, it depends on the character of the man who writes them, upon his ability, upon his frankness, upon many other factors, and the value of these factors cannot be estimated by the committee. I cannot conceive how we are going to reach the end we want through any such questions. I want to say right here and now, that anxious as I am for the facts that are aimed at by these questions, and earnestly desiring as I do that the whole electrical fraternity shall be acquainted with the facts regarding all insulations—among others the fact that no one insulation is the best for all cases—yet I say I do not believe it is a wise use to which this association may be put—to quote again the words of Mr. Morrison—to boom anybody's goods. I don't want the goods of which I have the honor to be the proprietor to be boomed by this association. I do not believe any other gentleman here wants these goods to be boomed in that way. Mr. President, I shall run the risk of some unkind person saying, "He did not want his goods tested thus," and put myself on the good nature of my brethren by making this motion, that this report be accepted and the committee discharged.

The motion was seconded.

The President—The pending motion is an amendment offered by Mr. Mason that the report be received and the committee discharged.

Mr. Morrison—I object to any such motion. I object to the closing of any channel of information for this association. I do not think that the shutting off of any source of information that may have been opened in times past will be of benefit to the association. I am glad to receive information from Mr. Mason or from any other gentleman engaged in his line. We all know what an honest—I would say a modest set of men the wire men

are. I would never accuse them of being very honest, but modest. But for my own sake and the sake of the other members of this association I hope the gentleman's motion will not prevail. That committee is composed of the most intelligent men in the various lines of business which they follow. If you discharge them you are at the mercy of Mr. Mason and the wire men. If you continue the committee you have got an intelligent body of reference to whom you can refer these matters, and if Mr. Mason comes to me and says, "I have got the best insulated wire in the world," and gives me his samples, I can go to the committee and say, "Mr. Mason claims such and such properties for his goods," and then these despised laboratory experiments come in very well, and you can take these to a chemist, and he will tell you whether the constituent parts of the insulator are such as will carry out the guarantee of the gentleman who offers the wire for sale. I ask that the gentlemen of this association will not vote to discharge that committee. It is a tough job to move to receive and approve a half finished report like the ones the committee has sent in for two or three years, but it is better than no report at all. They may wake up to the facts that the information is of importance to them, and take enough time from their slumbers or pleasures to make up a report that is free from blanks and queries. I hope you will vote down the substitute and accept the report such as it is, because it is the best we can get at present, and continue the committee.

The President—The chair desires to state, in all fairness, that this question has been before the association several times, and at the Boston meeting the committee was continued, upon the ground that sufficient money had not been provided by the association to make certain experiments in this direction, but they were instructed to collate information and make a report. Dr. Moses, for the chairman, stated that they had considerable valuable information. The point now is, if you adopt this amendment or substitute you will treat all that valuable information as practically of no use. It will be in nobody's hand except as an archive, and all the work that has been done will be lost. That is the way it presents itself to the chair. I simply state it so that you can vote intelligently. The question is on the motion to accept the report and discharge the committee.

This motion was lost.

The President—The substitute being lost the question now occurs on the original motion to accept the report and continue the committee.

Mr. Morris—I would offer, as an amendment, that we appoint an entirely new committee, partly of scientific gentlemen and partly of practical superintendents, and let us have a report on the facts as nearly as we can get them.

The President—Does Mr. Weeks accept the gentleman's suggestion?

Mr. Weeks—No, sir. I think it would be better to leave it in the hands in which it is now placed. They have organized a movement that will ultimately bear fruit. It is true that the first returns to these inquiries will be meagre, and the burden of them will be to condemn underwriter's wire, so called. But as times go on, it seems to me, if this matter is pressed vigorously and intelligently, as these men who have been placed on this committee have the ability and power to press it, that we will get some very valuable results. It strikes me too that we will get from the superintendents of the companies who are engaged in actually using these insulators the facts that we want. I appreciate the point of Mr. Mason that it is not in the laboratory alone that these things are to be settled. We might get certain results in the laboratory that would not be borne out by the varying conditions under which these wires are used. I feel that the wise course would be to leave this in the hands of the committee now appointed.

The original motion to accept the report and continue the committee was then put and carried.

The President—We will take up the paper of Mr. S. S. Leonard, of Minneapolis, on petroleum as a fuel. That will be now read by the secretary, or some member in his absence.

Mr. Allan V. Garratt read Mr. Leonard's paper on "Petroleum Fuel," as follows:—

PETROLEUM FUEL.

BY S. S. LEONARD.

The use of petroleum is by no means of recent date; it was known to the ancient Greeks and Romans, being used by them for illuminating purposes, as they had no electric lights in that day.

In fact the word "petroleum" is of Latin derivation meaning "rock-oil." It has been, and is, used for various purposes, from the sure cure of numerous diseases to the generating of steam for electric light stations. It is found in many parts of the globe, although there is but a few localities that are especially noted for its production. In our own country, New York, Pennsylvania, Ohio, and West Virginia produce the greater part of the supply.

Although it was known to the early settlers of these states, very little importance was attached to its value. I presume that there are none so young here but well remember the oil craze, and the saying which was heard almost daily of "So and So" has "struck ile." Perhaps some of the members of this convention were fortunate enough to strike "ile," and possibly some were unfortunate enough to have been struck by "ile." But to return to our subject, Petroleum Fuel: To say that it is a new fuel would hardly be correct, for petroleum has been used as a fuel for a number of years; experiments to determine its practicability as a fuel have been creating a great deal of attention from those interested in the matter for the last twenty years, and is now occupying the minds of some of our ablest engineers and inventors. Quoting from a very able paper on this subject by Chas. E. Ashcroft, which was published in the Boston *Journal of Commerce*, May 26th, 1888, Mr. Ashcroft says:

"That the calorific power of petroleum for the purpose of generating steam, and the evaporation of water is several times greater than that of ordinary coal." The successful use of oil as a fuel has, however, been of very recent date, yet so rapidly has it grown in favor that to-day it is regarded as a strong competitor of coal for steam generating purposes or where heat and fire are wanted. It was with a great many knowing winks and nods of the head from the engineers and firemen, who laughed at the idea of making steam by the use of oil, that the writer attempted the use of petroleum as a fuel; of course it would not work, and it did not work, why? because those who were using it did not want it to, as they were afraid some one would lose his job. We had seen enough of its workings to satisfy ourselves that it could be made a success, and the result is, that to-day we are saving from 20 to 25 per cent. on the cost of the fuel and 50 per cent. in labor, and these same men who laughed so hard on the start at our attempt to use oil would feel that this world was a poor place to live in, were we to return to the use of coal, for not only their hearts but their backs would certainly be broken.

Its advantages over other fuels are many; in the first place, it is much easier handled, a steadier fire is easily maintained under your boilers, consequently the steam is kept at a more even pressure, a very important thing in the running of electric lights; there is no opening of furnace doors, allowing cold air to come in contact with the boilers, and there are no impurities in the oil such as abound in coal; when through with it by a simple turn of the wrist your fire is put out, and your ash pits are as clean as they were before the fire was started; in less time than it takes to tell it you can start the fire. It is only rivaled in handling by natural gas, and even then, unless we have all the modern appliances for the handling of this gas, it is far easier to manipulate.

Permit me to describe the arrangements for the handling and use of this oil put in under the supervision of the writer.

The oil is received in tank cars holding from 90 to 150 barrels each (42 gals. to a bbl.), from these cars it is drawn off through a valve in the bottom of the car to a storage tank or tanks, there being two of them, holding about 320 bbls. each, these are placed underground so that the oil runs from the car into them by gravity; care should be taken not to spill the oil or stir it up more than is possible, as the odor from it is fully equal in strength to new mown hay if not quite as agreeable. To prevent the stirring up of the oil, the supply pipes entering through the top of the tanks run nearly to the bottom, so that the tanks are practically filled from the bottom. In the top of each tank are man-holes and a vent pipe; this latter is extended above the tanks a short distance. These tanks, which are boiler shaped, are placed end to end with a space of about eight feet between them, this gives room to get at the various pipes; they are joined together at the bottom by a pipe

which also connects with the supply pipe running to the boiler room; then in the bottom of each is a drain pipe which will admit of cleaning them out whenever necessary; there is also a gauge glass in the end of each to show how much, if any, water is in them; there is also a gauge, having a copper float, which indicates the amount of oil in each tank. In cold weather a small steam coil is inserted in the tank car around the mouth of the valve to heat the oil so that it will flow readily, for when the thermometer gets in the vicinity of 30° or 40° below 0 the oil is apt to be a little thick. Care should be taken not to heat the oil too much, for when hot it generates considerable gas, which is not only very odorous, but is really the cream of the fuel.

I think it an advantage to have the storage tanks underground, there being less danger from them in case of fire, and during the winter the oil is less likely to chill. An open light should never be used near them, although the oil itself is really hard to ignite unless heated to a certain degree; still there is apt to be more or less gas around, which is quite explosive if brought in contact with fire. The supply pipes to the furnaces are provided with a valve where they enter each tank, also one in the fire room; this pipe, a two and one-half inch one, is enlarged to a six inch for about four feet, and in this six inch pipe a small steam pipe is inserted; with this the oil is heated from 130 to 140 degrees, this lightens it so that it burns more readily, or I should say is turned into gas.

We now come to the burners, which are also fed by gravity, as the storage tanks, although underground are still higher than the furnaces.

One might suppose in view of the recent introduction of petroleum as a fuel, that some difficulty might be experienced in obtaining a burner, but their name is legion, and they are as numerous as electric light systems, and like them in another respect, each man's is the best. Our experience has been that the more simple the burner the better the result; one that thoroughly vaporizes the oil before burning it is, we think, preferable to one that burns the oil; in the former there can possibly be no waste. In furnaces where we have been using this kind of a burner the bricks are as clean as they were the day they were put in. Steam and hot air are the other ingredients that are used in connection with the oil, and an abundant supply of the latter we have found adds very much to the efficiency of the fire.

Regarding the proper settings, circumstances will determine that to a certain extent. An excellent plan is given by the Standard Oil Co., in their pamphlet on "Oil as a Fuel;" this we have adopted with a few modifications, which we found necessary by experience. There is no doubt but that a hotter fire can be obtained from oil than from coal or wood, and when properly used the smoke nuisance is solved which has been agitating the minds of the people of some of our large cities, for there is not a particle of smoke to be seen issuing from the stack, not even when everything is running full blast.

A word as to its danger. When properly put in and handled with ordinary care, or when good common sense is used in burning this oil, I cannot see why it should be any more apt to cause trouble than coal, although the insurance companies insist on higher rates when used. I think it more from ignorance of the subject than from there being any more danger; at the same time I am willing to admit that it could be put in and used in such a way as to greatly increase the danger of fire. So might your house be wired for electric lights, piped for gas, a kerosene lamp hung, or your gasoline stove filled, in such a manner that the fire risk is much greater than your neighbor's who uses electric lights, gas, kerosene or gasoline the same as you do, but has his put in properly and handles it as it should be. As to its economy over coal, I have already mentioned that there was a saving of from 20 to 25 per cent. on the cost of fuel, and from 40 to 50 per cent. in labor. From tests recently made by us, the following figures were obtained:—111.34 h. p., running six hours, used 250 gals. of oil, costing $5.50, or at the rate of 70c. per 100 h. p. per hour; 104.8 h. p., running six hours, used 3,461 lbs. of coal, costing $5.45, or at the rate of 86c. per 100 h. p. per hour. Another test gave the following figures: 96.45 h. p., running eight hours, used 4,014.75 lbs. of coal, costing $6.32, or 80c. per 100 h. p. per hour; 115.54 h. p., running 7 hours, used 233 gals. of oil, costing $5.05, or 62c. per 100 h. p. per hour. On the above figures, oil is from 17 to 32 per cent. cheaper than coal. The highest evaporation made with oil was 14.8 pounds of water per pound of oil, with feed water at 103; and with coal, 5.38 lbs. of water per pound of coal, feed water at 103. The coal used was a good grade of Illinois lump, costing $3.15 per ton, but which is usually worth $3.25.

In the matter of labor one man can easily attend from 7 to 10 boilers of 150 h. p., and then have less to do than he would were he firing one boiler with coal. After a week's run with oil your boiler flues are much cleaner than they would be from the use of bituminous coal for one night, especially Western coal. Your fire room can be kept as clean as your dynamo room. There being no ashes you are saved the expense of handling them as well as the dirt, and the former is no small matter where some twenty tons of coal are being used every twenty-four hours. I might say that the above tests were made during a part of the day's run, and it is our opinion that a more favorable showing could be made with the oil, where a larger number of boilers are in use. It seems to work better with a good fire than where a small fire is sufficient. With our pipe lines affording a cheap method of transportation the future of "petroleum fuel" is assured, and I think there is no doubt but with true Yankee ingenuity a burner, or some method, will be brought forward by which the use of petroleum as a fuel will be greatly improved.

The President—In connection with this paper I desire to read the following letter, as due to Mr. Leonard.

Minneapolis, Minn., Aug. 22d, 1888.

S. A. Duncan, Esq.,
Pittsburgh, Pa.:

My Dear Sir.—I herewith hand you the paper on fuel oil that you requested me to write when here. All that I have to say is that if you take the time to look it over, and think after doing so that it is not worth the while to take up time that would undoubtedly be spent to better advantage by having it read before the convention, do not hesitate to lay it one side, as no feelings will be hurt. Should you, however, think best to present it to the convention, I shall feel very well pleased if I have been able to say anything that will be of any benefit to the association. It will be impossible for me to be present.

Yours very truly,

S. S. Leonard.

I would just say that the way this matter came about was that being in Minneapolis some weeks ago I walked into Mr. Leonard's station and wanted to know where he got natural gas, and laughingly he said, "We use gas in a different way." Then the question came up as to the economies and so on, and I found that he obtained such satisfactory results from the use of petroleum, and was so entirely satisfied with the economies as compared with his former experience with coal, that I asked him to prepare this paper and it is now before you for discussion. I hope you gentlemen will go into it.

DISCUSSION.

Mr. Morrison—As Mr. Garratt was reading Mr. Leonard's paper I asked Mr. Pope to analyze those figures. Here they are: 250 gallons of oil cost $5.50; that is seventy cents per 100 h. p. per hour. Coal costs eighty-six cents per 100 h. p. per hour, a difference of sixteen cents per 100 h. p. per hour. If you take a station of five thousand or six thousand horse-power and run a year that is a considerable item.

This paper is a very startling one to me. I saw it yesterday I think. It is a most startling one if the details are true. We have no reason to doubt the statements; I have none. If any gentleman has made any experiments in that direction that will throw a doubt on these statements I hope he will get up and say so.

In 1865, that is twenty odd years ago, I was a telegraph operator at Parkersburg, in West Virginia. They did not get coal enough for their use. There was a man named Shipley who was engineer in the Swan House, a tavern right across from the

telegraph office, and there for the first time I saw the burning of petroleum. There was plenty of it there then. Wood County had got into the habit of squirting oil out of the ground, as in Pennsylvania, and oil was very cheap. I think it is cheaper to-day than it was then. If this is true I want to know something about it for we will be running six or seven thousand horse-power within the next six months or so. There is another item not mentioned in the paper. It costs us twenty-five cents a load, with coal, to haul the ashes away. I have not at the end of my tongue the figures of our station. I am sorry Mr. Evans is not here to give them, but we use a low grade of fuel. It costs a little less than three dollars a ton. It is known as screenings and soft slack coal. It has always been an open question with me whether there was very much economy in the end with it, but it costs well up to three dollars before you get through with it. Now it costs you three men to handle it, and out of this trash that you burn the ashes are nearly fifty per cent of the fuel you put on the grate bars. Of course you must make allowance for these statements because I am making them off hand. But I observe if we burn say fifty or sixty tons of coal of a night we generally have thirty or forty cart loads of ashes to haul away the next day. Now that goes to show that pretty near half of the stuff comes out in the form of ashes, sand and slate from the mines, and so on. That is another item that you can credit up to the economy of this petroleum fuel. In the new station we are going to build I shall equip one battery of boilers with coal oil. Mr. Weeks, of Kansas City, is going to make large additions to his plant, and I hope he will do exactly the same thing. What do you pay for coal in your country Mr. Weeks?

Mr. Weeks—$2.56.

Mr. Morrison—What kind of coal?

Mr. Weeks—Bituminous nut.

Mr. Morrison—How much do you use per horse-power per hour?

Mr. Weeks—About six pounds.

Mr. Morrison—On a Buckeye engine?

Mr. Weeks—No, Hyde engines.

Mr. Morrison—I would suggest that every gentleman who is a member of this association and who contemplates any additions to his plant will take a copy of this paper and analyze it carefully. If there is something he does not understand let him ask Mr. Leonard to explain it and then try it practically himself.

Mr. Frank Ridlon, Boston—I have been superintendent of a large coal tar company. From that material we got out various substances that were valuable for coloring matters. We finally came to the last portion or that which was known as dirt oil. It was used at that time for the making of glass, and was also sold latterly at a somewhat higher price for the creosoting of wood for railroad ties, spiles, etc. We at one time found it impossible to get a sale for that article, and when we had to sell it for about a dollar a barrel we found it cheaper to burn it and we did burn it with very good satisfaction, although the apparatus for using it was very crude indeed, not only as to the economy of heat but as to the wasting of fuel. We simply had a perforated plate and another plate that was not perforated underneath and let the oil drip down upon it; but we found it a very fine material to use. Referring to the matter of ashes, that was quite an expensive matter—carrying some distance; so that when we could not get a dollar a barrel for it we found it cheaper than burning coke for which we were then paying about $2.50 a chaldron.

Mr. DeCamp—I would like to ask how long Mr. Leonard has been using oil.

The President—The chair will state that he was there about the 10th of July, and Mr. Leonard had then been using that oil several months. He had first made the experiment with smaller quantities of oil, but the company had got to that point where he had put these tanks in as reservoirs, and they ran in a side track alongside his station and emptied into his reservoir tanks. It is as clean and nice a piece of business as I ever saw.

Mr. DeCamp—Mr. Leonard's paper is a very remarkable one. Some two or three years ago I paid some considerable attention to the subject of oil fuel. Several methods have been adopted in Philadelphia for the utilization of oil, but the parties who have adopted them have finally abandoned them. I was never able to learn just what their reasons were but they used them with apparent success for some time and, as they said, with great economy, and then they dropped it. As I see, figures are presented in Mr. Leonard's paper on the first cost of oil fuel as compared with coal. There is not a very material difference, but the labor item and other expenses extended to coal which would not be extended to oil is quite sufficient to make the matter of very great interest to this association. I have recently got through with a test of coal. We have been using one particular coal for about four years. In fact we do not seem to be able to get any other coal that is equal to it; our recent test was made with a new coal as compared with the coal we are now using. There was a difference of eighty-five cents a ton in price. Our coal cost us in one instance sixty cents per hundred horse-power per hour and in the other, sixty-three cents; the sixty-three cents being far the lowest priced coal Now we differ from Mr. Morrison; we do not use screenings. I have come to the conclusion in the last two or three years that the best coal was, taking all things into consideration, the cheapest coal to use. In the one case the cheaper coal gave about three and a half cart loads of ashes to every ton of coal, and in the better class of coal it was a trifle less than two. Our ashes cost us, from one station seventy-five cents a load to haul and from another station forty cents. In the comparison between these two coals on the point of labor, the better coal would run a full fourteen hours without the fire being cleaned, and with the other coal we would have to clean fires certainly sometimes during the run. That would necessitate another man as a laboring man in the fire room. I made up the estimate on those two coals. There is a difference of eighty-five cents a ton in price between them. The labor and everything else taken into consideration was equal to about $1.10 a ton. One coal cost us $2.90 put in the boiler hole and the other cost us $2.75. Our consumption of coal is about 12,000 tons a year. The figures presented by Mr. Leonard are just about on a par with the best coal we use; so that there is no doubt of the importance of that paper, if Mr. Leonard is correct in his figures.

Mr. M. J. Perry, Providence, R. I.—Mr. President, the gentleman from Baltimore who is using coal dust and soft coal mixed has had an experience quite different from mine, although the net results of Mr. De Camp's experiments and also the net results of the experiments of Mr. Morrison were very similar, and they seem to be very much like the result of using the oil fuel. That is to say, about 62 one-hundredths of a cent to 66 one-hundredths of a cent per hour per horse-power. Last autumn our company having decided to build a new station, and having determined on some radical changes in the arrangement of the steam plant, I thought it would be an excellent thing to put on some first-class steam engineers and ascertain, not what we might do by fancy firing and jockeying, but to ascertain just what we were doing in every-day practice, and we selected for that purpose a gentleman very well known, who was trained under Mr. George H. Corliss—Mr. John T. Henthorn, a member of the American Society of Civil Engineers and also of the Society of Steam Engineers, and asked him to determine what we were doing. We made no changes whatever. The result was a horse-power for about 62 one-hundredths of a cent per hour. We used for fuel three parts of anthracite dust—not pea and dust but simply the dust; no pea in it whatever; with one part of Pocahontas or an ordinary flat-top coal. The result of that was about 17 per cent. of ash. Mr. Morrison spoke of 50 per cent. and that caused me to mention this—about 16 or 17 per cent. Our runs were good runs. We made 48 hours straight tests, running right through two days and two nights. Having some power business and also some all day business we run our stations 24 hours. The result was—which confirms the statement of Mr. Morrison and also that of the gentleman from Philadelphia—about 62 to 66 one-hundredths of a cent per hour per horse-power, and in the ash, as I say, about 16 or 17 per cent. in weight. Now another very peculiar thing was that when we just concluded our first day's run, it came on raining and continued to rain for the next 24 hours. So far as we were able to ascertain there was not a change of a single light. The same hours were run, the same number of lights were run, but the run during the rain showed an increase of 20 h. p., the average of the 24 hours being at the rate, I think, of about 142 h. p. per hour for the first 24 hours. The second day, when it was raining (it poured the whole 24 hours), it was just 162 h. p. per hour for the 24 hours. We are using underwriter's wire all the way through. We have no especial interruption from the grounds, but general leaks all along the line. The results of coal using and of oil burning seem to be about the same in the four stations—the Baltimore, the Philadelphia, the Minneapolis and the Providence station.

Mr. Morrison—I would rather take the gentleman's statement than my guess work. The gentleman has stated these as actual facts from tests.

Mr. Perry—Yes. Our engines were indicated every 20 minutes.

Mr. Morrison—Now in regard to the ash?

Mr. Perry—As we intend to abandon the high speed engine—I should say the high pressure engine (we propose to run high speed the same as before but we will use a compound engine and surface condenser) I wanted to know just what we were accomplishing with the high pressure engine, and to ascertain what benefit we would derive from adopting the other engine. We shall go into the new station in the course of three or four months. We used an Armington & Sims engine. We have not yet fully decided what engine we are going to use except that it will be a compound engine with surface condenser. We intend to arrange the station so as to get a uniform load while operating the engine.

The President—Did you include the cost of hauling refuse matter?

Mr. Perry—No, sir.

The President—Then you can figure 20 per cent. at least for that.

Mr. Perry—It costs us 28 cents a load to haul the ashes.

Professor Van der Weyde—A year ago I had a rare opportunity to test the economy of coal compared with petroleum. I was testing a new style of dynamo in order to determine the economy of the alleged improvement. The parties interested in it concluded to make another test, and by means of petroleum fuel.

The petroleum boiler was furnished with the furnace. I had the consumption of petroleum watched carefully. I have not in my memory the correct figures, but I can tell you the upshot of the results obtained. The dynamo was tested also. The steam power furnished to it I had carefully tested with indicator diagrams. I made the test as well as a conscientious scientific application could make it. The result was that when compared with the consumption of coal, the petroleum was a great deal dearer notwithstanding that the coal is more expensive here in New York than in many other places. I remember the upshot only, which was this—that as long as crude petroleum will cost more than 40 cents a barrel it is cheaper to run with a slack coal. In stating that result to a prominent Philadelphia manufacturer he told me that they had had the free use of gasoline from some petroleum furnace there, and so they used it for a time until the gasoline got more valuable in the market and they could not get it gratis any more. Then they stopped, because if they had to pay for the gasoline it would be much cheaper to use coal, and they returned to the use of coal. Only where the peculiar circumstances admit of getting petroleum cheap can it be used to advantage. For instance, in Russia they use petroleum largely because they have no coal; but in the City of New York I am perfectly satisfied that notwithstanding there is some saving in the handling of the fuel when we use petroleum, that coal is the cheaper fuel in New York city.

Mr. Morrison—What did you pay for the petroleum, Professor Van der Weyde?

Professor Van der Weyde—The petroleum was $1.00 a barrel.

Mr. Morrison—I want to find out what this experiment is based on—the price per gallon for oil and the price per ton for coal. I want to ask the gentleman upon what this experiment was based—the cost of the oil, the cost of the coal, the length of the test, etc.?

The President—Can you inform the association, Professor, the length of time of the test, and the cost of the fuel of each description?

Professor Van der Weyde—The test for petroleum was for about a fortnight.

Mr. Morrison—How large a plant?

Professor Van der Weyde—The plant was small. I must confess that the plant was not more than enough to furnish about 20 h. p.

Mr. Morrison—You used crude petroleum I suppose?

Professor Van der Weyde—Crude petroleum.

Mr. Morrison—It cost you how much?

Professor Van der Weyde—A dollar a barrel. I made a calculation at that time that if we could have had the petroleum at 40 cents a barrel, then it would be cheaper. I must also say that the arrangement for consuming the petroleum was very fine—one of the best I have seen, while the arrangement for the coal consumption may not have been so perfect. It was an ordinary horizontal boiler.

Mr. Morrison—What did you pay for the coal?

Professor Van der Weyde—I believe it was $3.50 a ton delivered at the place.

Mr. Weeks—What kind of coal.

Professor Van der Weyde—Anthracite coal?

Mr. Morrison—Do you think that experiment would be as reliable as using say 100 h. p.?

Professor Van der Weyde—That is a question I would decline to answer. My experiments were with an engine of about 20 h. p.

Mr. Morrison—What was the difference in the cost?

Professor Van der Weyde—I have not the figures in my mind, but I know this, that the result of my calculation was that when we could get petroleum for 40 cents a barrel then we could make steam as cheap as with the coal.

Mr. J. M. Pendleton, New York—In view of the discrepancy in these results I thought it might be interesting, referring to Mr. De Camp's experience, to ask him whether he had ever heard of a petroleum fire burning the iron. I recollect many years ago that that was the complaint of many engineers, and it might be interesting to know if he ever heard of such a result being caused by the use of oil as a fuel.

Professor Van der Weyde—I am glad Mr. Pendleton mentioned this, because in my observation for 14 days in a petroleum furnace I saw that the iron suffered greatly, and I was expecting that if it was used for a protracted time it would give out.

Mr. De Camp—I never was able to learn anything about that. The last and most important effort made in that direction that I know of was in a shoe factory. The proprietor is a man of large means, and a progressive man, and he had very small facilities for coal storage and he went to a very considerable expense, I judged from the looks of his place, to put in the boilers for oil fuel suitable for his factory. I suppose he used 50 h. p. I do not know whether he ever published them or not, but he made statements very freely that he was saving a great deal of money in his fuel account. I do not think he ran more than six months when he abandoned it. Whether he found his boilers were burning out or not I never heard.

Professor Van der Weyde—Another illustration comes to my mind. At Hastings, N. Y., there are gas works where petroleum is used to be converted into gas. They commenced with coal as fuel and after a while they tried petroleum, and instructed by the experience I had had before with a dynamo I told them I did not expect they would be satisfied. It turned out that way. They abandoned the use of petroleum and returned to the use of coal.

The President—The hour for adjournment is getting very near, and this is a very interesting subject. This question of burning out boilers with gas is all nonsense—with petroleum gas—because it is identical with natural gas when it is properly burned under boilers, and there are many boilers used with natural gas burning under them lasting longer than any with coal under them. In regard to the question of economy, the only thing I know about it is the statement of Mr. Leonard. Mr. Leonard is a practical man and is running a good sized station, and I have no doubt he will stand up the figures he has given. If the points made are such as to induce this association to have a committee to see if they can get a few more statistics on the subject, it would be well. But so far as the present discussion is concerned, it will have to close at this time.

Mr. Morrison—I hope we may be able to hear from Mr. DeLand before adjourning.

Mr. Pendleton—I beg to say in reply to Mr. Duncan's remark that the action is different in burning gas under water and burning the petroleum in the manner spoken of by Mr. Leonard. In one case you have the pure gas burning and in the other case you have a mixture of steam and hot air with it. It is a well-known chemical fact that at white heat, usually, steam is decomposed, and the action of this mixture upon the iron in the vicinity would be very different from that of pure gas. I only call attention to the fact that the burning of natural gas by no means solves the question of burning petroleum where hot steam and air are burned with it.

Mr. B. E. Sunny, Chicago—The company that I am connected with has a station just south of the city limits in Chicago. Our coal costs us about $900 a month. We were buying it by the car load. The coal was wet at the mines; it was generally wet when it was weighed, and by the time the car got to us we found it short about 20 per cent. in weight, so we got about $700 worth of coal and paid $900 for it. On investigating this question of oil burning, and corresponding with a large number of gentlemen who had some experience and who had been using oil burners for a long period, we found that in most instances the same results could be had out of two barrels of oil as out of a ton of ordinary bituminous coal. Our coal was costing us about $3.00 a ton. We could buy oil for 60 cents a barrel, so that the equivalent of one ton of coal would be $1.80, making a saving of $1.20 on a ton of coal. The saving that we expected to get on the change from coal to oil figures at the difference between $957 a month and $540 a month, and we make a saving of $45 for the salary of a coal passer, and $12 for hauling the coal in and taking care of the ashes. We expect to make in any event a saving of 35 per cent. although the figures guaranteed to us by the men who are handling oil burners, and the figures are said to be reliable by men who have experimented, would indicate that there will be a saving of 40 per cent.

With regard to Mr. Leonard's figures as to the economy, I should say that this fact ought to be taken into consideration; viz., that the oil cost him perhaps two and a quarter cents a gallon in Minneapolis, while it costs a cent and three-quarters in Chicago. With regard to the burning out of the boilers, I found that that largely depended on whether you could distribute your flames all around the boiler, But there are several methods whereby you can distribute your flame so equally that there will be no effect on the boiler whatever, and you can get the same result out of the use of oil as you get from the use of coal with respect to the burning of the boilers.

Mr. Fred. DeLand, Chicago—Mr. DeCamp asked how long the experiments at Minneapolis had been carried on—about nine months if I remember rightly. It was started the latter part of December or January. There is an experiment going on at New Orleans that will probably be interesting. It is the Louisiana Electric Light and Power Company. Morris J. Hart is the general manager, and he would probably give you gentlemen all the information you desire if you correspond with him. I was down there several months ago. It is stated he has the largest station in the world in capacity. He has a capacity of nearly three thousand arc lights. The horse-power, I believe, is over 1,200. He had been in the habit of purchasing his coal and having it shipped in barges down the Ohio and Mississippi River, and wheeled in barrels 400 yards from the dock into his station. He found that by using oil he could save thirty-one per cent., and he brought that about in this way: He purchased his oil, of course, from the Standard Oil Company. He sunk two large tanks in the ground each containing 100,000 barrels of oil. The switch passes his station. The cars are brought down to the tanks, emptied there and taken back. The saving came about in the wheeling out of the ashes, the cost of hauling the coal from the barge to the fire room, the doing away with one or more firemen, and other little incidentals; but the net result at that time was a saving of thirty-one per cent. over the cost of burning coal. I

know that Mr. Hart would gladly give this information to any one who would correspond with him.

Mr. F. R. Colvin, Baltimore—I was at that station a few days ago, and the situation there is interesting. Mr. Hart has one battery of boilers running by petroleum and another running by coal right next to it. I could not give any technical data, but I could get it of Mr. Hart. Mr. Hart's brother I believe is in the city.

The President—This is certainly an interesting discussion, but we will have to pass it and adjourn until to-morrow morning at such hour as will suit the convenience of the convention. Before doing so I desire to announce the committee on place of meeting, which will be as follows: C. A. Brown, of Chicago, E. R. Weeks, of Kansas City, T. Officer, of Council Bluffs, A. J. DeCamp, of Philadelphia, and H. D. Stanley, of Bridgeport.

The first business to-morrow morning will be the underground question, and an exhibition, I understand, will be made for the information of the gentlemen of the convention.

The convention then adjourned until Thursday morning at 10 o'clock.

SECOND DAY'S PROCEEDINGS.—THURSDAY MORNING'S SESSION.

The President—Gentlemen, this morning's session is to be devoted exclusively to the question of underground conduits or conductors in the City of New York.

We will first have read all communications and clear up the general business on the secretary's table, after which we will take up Dr. S. S. Wheeler's paper, then the paper by Mr. E. G. Acheson, and then the one by Mr. A. C. Chenoweth.

The secretary has some communications to read.

The secretary then read a communication from Mr. Somerville P. Tuck, as follows:—

August 27th, 1888.

HON. S. A. DUNCAN,
President National Electric Light Association,
Brunswick Hotel, City.

Dear Sir—I have taken the liberty to send you by mail this day a package of one hundred circulars relating to the Paris Exposition of 1889.

Mr. Abdank-Abakanowicz, the representative of the syndicate which has contracted for the lighting of the exposition, is now in this city, having brought to this commission an official letter of introduction from M. Georges Berger, the Director-general of the exposition. I enclose you a clipping from an electrical paper which will give you the details of his mission. I also enclose you blank form of application for subscription to the stock with extracts from the by-laws of the syndicate.

At the request of commissioner-general Franklin, Mr. Abdank cabled the president of the French syndicate on the 22nd instant, asking if they would receive until October 1st subscriptions to its stock on the part of American electrical companies, should such companies desire to subscribe, and in answer thereto a cable was received from the president to the effect that no engagements could be made as requested but that the syndicate would do all in its power to receive subscriptions made previous to October 1st next. Mr. Abdank informs me that he will await your convenience and be ready to make all explanations that may be desired in regard to the matter in which he is interested, and I am sure that he will receive a most cordial reception and due attention.

Thanking you in advance for anything which you may be able to do for him, I am your obedient servant,

SOMERVILLE P. TUCK,
Assistant Commr.-General,
Per. R. W.

The President—This communication will be received and filed, and the gentlemen who desire to look into the matter will find blanks on the secretary's table, and I think, in view of the importance of the general exhibit which is to be made at that time, that we will all be interested in at least looking up the matter.

The secretary next read a communication from James Allison, president of the Centennial Exposition of Cincinnati, as follows:—

Secretary's Office, Cincinnati, Aug.

DR. OTTO A. MOSES,
Chairman Executive Committee, Nat'l Elec. Light Assoc'n,
131 East 73d St., New York.

Dear Sir—The commissioners of the Centennial Exposition of the Ohio Valley and Central states wish to call the attention of the members of your association to the electrical features of the exposition, and wish to submit a brief statement of what is to be seen in that line together with an invitation to all who can do so to visit us.

It has been the intention of the commission to make electric lighting a special feature of the exposition, and they have taken especial pains to have a variety of systems shown and to display the apparatus to the best advantage. As a large amount of light was required for illuminating the buildings, arrangements were made with five manufacturers of electric light machinery for the use of their apparatus, the exposition using the same for service, and the companies having the advantage of large exhibits in regular service.

The following companies are furnishing apparatus:—

The Westinghouse Electric Co., Hartford, Conn., 8 dynamos and 230 arc lamps. The Western Electric Co., Chicago, Ill., 8 dynamos and 225 lamps. The Mather Electric Co., the Edison Co., and the Queen City Co., of Cincinnati 2-500 light dynamos and 1,000 incandescent lamps each. Four of these plants arranged in a combined station situated in the Park building, each lamp driven by a separate engine, the whole making a fine exhibit, the other being located in the Pioneer Hall, on account of its being arranged for after the general plant had been designed.

The lamps are distributed all through the buildings, being used for illumination and decoration; about 500 incandescents being used for the Art Gallery, about 600 for show cases, 900 for decorating Music Hall, 150 lamps for lighting the Park building and the Government Exhibit, and as many more for the Machinery Hall, and about 100 for the out-door illuminations.

This latter has been made a special feature, and show the effect of tower and street lighting to perfection. Besides this there are several private exhibits of incandescent lights and some motor exhibits, among them a 50-h. p. generator and about 25 small motors exhibited by the Queen City Co. An exhibit of constant current motors by the Card Motor Co., of Cincinnati, O., the current being furnished by a Waterhouse Dynamo, and two 2 h. p. motors furnished by the Mather Electric Co. In addition to this, the commissioners arranged, at great expense, with the local Edison agents for a decorative and novelty display, which has proven a great attraction. About 2,000 incandescent lamps are used in designs such as illuminated fountains and cascades, umbrellas, Christmas trees, revolving flower gardens, etc., the lamps being flashed at intervals, giving a very fine effect.

We hope the members of your association will find it convenient to come and see this display, and we think they will be well pleased.

Yours very respectfully,

JAMES ALLISON,
President, Centennial Exposition.

The President—The communication will be received and filed.

Mr. Foote, of Cincinnati—In behalf of that communication, Mr. President, I wish to say that the Centennial Exposition in Cincinnati will probably show the best electrical exhibits ever seen in this country. We are to have a grand display showing electricity in competition with gas, and I think it would be well for every member of the association to go to Cincinnati and see it. I would make the announcement, in behalf of the commissioners of the exposition, that the members of this association who will call at the secretary's office and present their cards of membership in this association will be given tickets of admission to the exposition.

The President—Gentlemen, you have heard the statement that those who bear cards of membership in this association and who intend going to the Cincinnati Exposition will have a card furnished them which will admit them to the exposition free.

The secretary next read a communication from W. H. Eckert, announcing that the Metropolitan Telephone and Telegraph company had placed a telephone in the hotel for the use of the association.

The secretary next read a communication from A. S. Hibbard, announcing that the American Telephone and Telegraph company had placed a long-distance telephone in the hotel for the use of the association.

On motion the thanks of the association were voted for the courtesies extended in the letters of Mess. Allison, Eckert and Hibbard.

The secretary next read a communication from Mr. McDonald, of Fort Wayne, Indiana, and also a communication, attached to the former, from Mr. R. B. Rossington, as follows:—

Fort Wayne, Ind., May 30th, 1888.

MR. W. H. HARDING,
Sec'y National Electric Light Association,
11 South St., Baltimore, Md.

Dear Sir—Enclosed find copy of lecture from R. B. Rossington, freight agent at Fort Wayne, which will explain itself. We should be very glad, indeed, if you would take this matter up with the traffic association committee, and see if the classification on carbons cannot be changed; as it is, the freight charges are exhorbitant. Any assistance that we can render in this matter will be cheerfully furnished.

Yours truly,

FORT WAYNE JENNEY ELECTRIC LIGHT,
By R. T. MCDONALD, Treas.

———

Fort Wayne, Ind., May 28th, 1888.

MR. R. T. MCDONALD,
Treas. Fort Wayne Jenney Electric Light Co., City.

Dear Sir—Your letter of the 15th inst., relative to excessive rate on shipments of carbons from Pittsburgh, has been referred to Mr. Orr, division freight agent, Pittsburgh, Pa., who makes the following reply: "Electric light carbons boxed are classified as first-class, at which shipment in question was billed. It would

be necessary to have a change made in classification before we could do anything, and besides we have had no complaint from shippers." Judging from the above from Mr. J. P. Orr, I would think it advisable to take matter in with shippers and have them petition the central association committee for a change of classification of carbon, as it is necessary that shippers as well as consignees shall make complaint of such matters before they will be entertained by the company.

Yours truly,

R. B. ROSSINGTON,

Freight Agent, Penna. Co.

The President—Gentlemen, you have heard the communication. It will be received and filed, and the chair would suggest that each member of this association engaged in the lighting business should file with the secretary a petition regarding the question of the classification of freight rates for carbons. That being done we will then take up the subject through the executive committee and may possibly be able to obtain something that will benefit us all. There being no objection, that will be the action and the communication will be referred to the executive committee. The secretary has already, under direction of the executive committee, sent out communications to the different companies, but has received very meagre responses. Now, gentlemen, it remains with yourselves whether you will take this subject up and press it. The secretary can do nothing until he receives sufficient petitions to act upon. If gentlemen will promptly file petitions, or a statement of their views in regard to this matter with the secretary, the executive committee will at once attend to the matter.

The secretary next read a communication from Professor Elihu Thomson, tendering his resignation as chairman of the committee on insulation and installation.

The President—Gentlemen, you have heard read the communication of Professor Thomson resigning his position as chairman of the committee on insulation and the installation of plants. What shall be done with it?

On motion, duly carried, Professor Thomson's resignation was accepted.

The President—The next question is, shall the chair appoint some one to fill the vacancy, or shall it be left to the committee to select their own chairman?

On motion, it was ordered that the vacancy in the committee be filled by appointment of the president, and that the chairmanship be left to the selection of the committee.

Mr. A. R. Foote, Cincinnati—Before we proceed with the reading of papers, Mr. President, I ask permission to offer a resolution touching the address of Mayor Hewitt yesterday.

The President—The resolution may be read.

Mr. Foote—I offer the following resolution :—

"*Whereas*, The Hon. Abram S. Hewitt, Mayor of New York city, has honored this association with an address of welcome; and,

"*Whereas*, in his address he has given a concise and impressive presentation of the importance to civilization of the utilization of electrical force in the mechanical service of the people, which is second to none ever before offered ; and,

"*Whereas*, In so doing he has announced sentiments indicative of the man in his complex character of philosopher, statesman, politician and master of business affairs ; therefore,

"*Be it Resolved*, That as a mark of appreciation of his masterful grasp of the importance of the subject, his clear-sighted and generous presentation of it, and his kindly courtesy, the secretary of this association be and he is hereby directed to print an authorized copy of said address in pamphlet form, and supply the same to members of the association at a price ten per cent. in advance of the cost of production."

The adoption of the resolution was moved and seconded.

The President—Gentlemen, you have heard the resolution read. What is the pleasure of the convention?

Dr. Moses—I would respectfully suggest to the mover of the resolution that the question of cost of the pamphlet be entirely eliminated from it, and that instead of the publication of the address,—since that address has been read by several millions of people this morning in the newspapers, there is no necessity for us to circulate it ; it will become a part of the printed proceedings of our meeting, anyway,—I would suggest that the thanks of this association be tendered to the mayor, simply.

Mr. Foote—Mr. President, I wish to explain why I offer the resolution. I want to get the address in full, in an authorized shape from this association, for a use which I think will meet the approval of every person here. In Mr. Hewitt's remarks about the importance of the re-distribution of power to the people, he expressed identically the same sentiments that I heard expressed within the last four weeks by the president of the Commercial Club of Cincinnati. About two weeks ago I was requested by an officer of one of the leading banks of Cincinnati to go with him to the exposition and show him the electrical exhibit there in its commercial relation. He brought with him an officer of the National Banking Association. The National Banking Association will hold their meeting in Cincinnati in October. Their question to me was : Will the stocks of electric companies become dividend paying stocks? That is the point they are looking after. Now, I wanted to get this paper in an authorized shape to distribute to the members of that National Banking Association. I believe there are some three thousand of them, and I am ready to give my personal order for 3,000 copies of the pamphlet if it is issued. I wish to say also that I would like to have the pamphlet prefaced by the address of our president in opening our sessions, showing the scope and the meaning and the importance of the electrical industry as it now stands.

Mr. Arthur Steuart, Baltimore—I want to add my approval to this resolution and my voice in favor of having the matter carried out. I listened with the utmost pleasure to the address of Mr. Hewitt yesterday, and I am sure that I express the feeling of every member of this association when I say that it is the very best presentation of the importance of this subject in which we are all interested that has ever been made. It is the most practical, sensible and intelligent presentation of this very difficult and much mooted question of what is to be done with the electric light wires that has ever been put before us or called to the attention of the public. Now, I know that it is so in our own town, and I feel that it is equally the case in almost every town in which our delegates live ; that the authorities are ignorantly striving to do just what Mayor Hewitt told us they had been striving to do in this town,—trying to put the electric light wires underground, without any knowledge whatever of the conditions necessary ; and I think that the address of Mayor Hewitt, coming as it does from a man who stands prominently before the people of this country, not only as the mayor of the greatest city in the land, but also as one of the recognized leaders of the best and most intelligent thought among the people, will go far to quiet the difficulties that all of us have met within the municipal bodies of our cities upon this subject. I therefore hope that the resolution will be adopted, and the address circulated as widely as possible.

The President—Are there any other remarks on the resolution? The scope of the resolution is that we take the address of Mayor Hewitt from the official notes of our own stenographer with the endorsement of this association, it being one of its official papers, and print it in pamphlet form so that the members of this association can have as many copies as they please for distribution.

The resolution was adopted.

Dr. Moses—It has been very properly suggested that the remarks of Mayor Hewitt yesterday, while being very commendable and beautiful, yet rested upon a foundation. That ought to appear too in the pamphlet, because he spoke at length of the progress of the industry which was so clearly set forth in the report of the president. Now, it would perhaps be a good idea to embody the two, since they had reference to the same subject. I would therefore make this motion : That the report of the president be added to this pamphlet which is to be published ; that is to say, that the report of the President and the address of Mayor Hewitt be printed in the same pamphlet for distribution.

It was voted to include president Duncan's address in the pamphlet.

Dr. Steuart made a motion that the chair appoint a committee of five to consider the recommendations of the president in his opening address, and report at this convention.

The motion was duly carried.

Dr. Schuyler S. Wheeler, of New York, then read a paper on "Overhead and Underground Wires in New York," as follows :—

OVERHEAD AND UNDERGROUND WIRES IN NEW YORK.

BY DR. SCHUYLER S. WHEELER.

Mr. Chairman and Gentlemen of the Convention :

It is my purpose, in as brief and concise a manner as possible, to give you some idea of the condition of the overhead and underground wires in the City of New York, and the means which are being adopted by the public authorities to bring about a better state of affairs than the one now and for some time existing.

In 1884, the Legislature of the State of New York enacted a law to the effect that electrical companies in the cities of New York and Brooklyn should place their conductors underground. The local authorities were expected to enforce this law, and the maintenance of electrical conductors overhead in these two cities after a certain day was declared to be unlawful.

Of course, the business of telephoning, telegraphing and electric lighting could not be disposed of so summarily, and before the day appointed upon which the maintenance of wires overhead was to become unlawful fell due, the Legislature enacted in 1885, a law providing for the establishment and organization of a commission, the purpose and object of which was to provide a plan by which electrical conduct

tors in the cities of New York and Brooklyn could be placed underground without interfering with the efficiency of the electrical service. By this law of 1885, it was provided that companies could submit to the commissions established in the twin cities, plans for placing their conductors underground, and should the said plans meet the approval of the commissioners, the companies submitting them could thereupon proceed to place their conductors underground according to these approved methods.

In 1885, the question of placing electrical conductors underground was very generally disputed, and no companies submitted plans to the commission within the required time. It thereupon became the duty of the commissioners of electrical subways to devise a method by which electrical conductors could be placed underground and to compel companies to carry out the work according to this method.

The subject was then comparatively new, the difficulty not fairly comprehended, and the different kinds of service, as well as the ways in which the wires might be put underground, were not even classified.

The result of the investigation made by the commission to ascertain by what method wires could best be placed underground in cities was that the commission had to listen to about 450 plans, many of them having nothing to do with the work to be accomplished, and many of them utterly absurd.

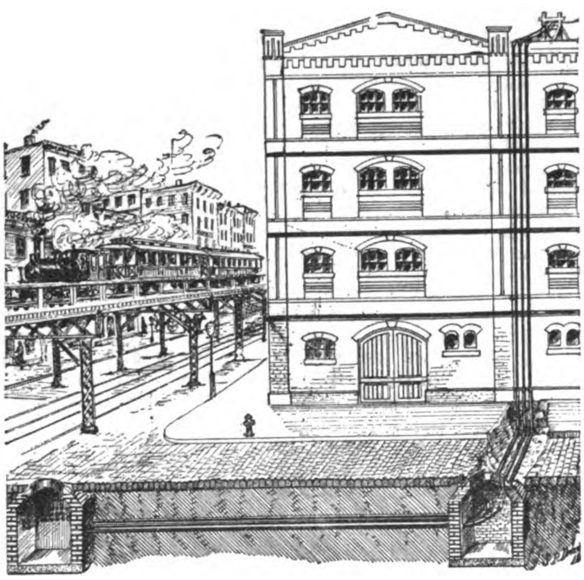


FIG. 1.—House-top Distribution, Sixth Avenue and Fifty-first Street, New York.

Notwithstanding the impression that underground wires were a common thing in other cities, especially abroad, nothing had been done that would serve as experience for this city. In many places wires had been laid underground singly, in pipes, in sewers and in cables; but no such piecemeal plan could be allowed in a city having more telephones, more telegraphs, more electric lights, and less available area, than any other spot in the world, in proportion to the amount of business going on. To be of any value, under such circumstances, a plan had to be found which would permit new wires being put in from time to time, almost without limit, without disturbing the pavements of streets, and of sufficient capacity to accommodate the large number of wires, for which a sufficient space underground could scarcely be found between the various obstructions already buried.

The difficulty of the problem, and the reason why the experience of other places are of so little value to us, will be seen when it is considered that the number of wires in a given space in New York, taking the average, is very much greater than in any other centre in the world.

The places between which these wires run, instead of being in an approximately circular area, as in the case of the three other leading electrical cities, are drawn out on a long and very narrow island, thus crowding the conductors together and increasing their length between points. In addition to the difficulty of a much greater amount of wire and less area to contain it, there is the great difference in rapidity of business, which makes it necessary to be able to put up and remove wires and instruments here more speedily than in the older cities.

The ground was so filled with gas, water and steam pipes, sewer and pneumatic despatch tubes, and their connecting boxes and man-holes, that it was impossible to find a straight course for a conduit or even a small number of ducts; and the repairs to these, which are continually going on, would make the wires specially liable to disturbance and injury. The earth is saturated with gases from the various pipes and this would collect in any open space, such as the subways would afford, destroying the insulation of the cables, suffocating the workmen, or causing explosions. In comparing wires with gas mains, it is sometimes said that the former are much more difficult to bury successfully than the latter, because the leakage does serious harm, while the leakage from the gas pipes is of no consequence. It is true that the loss from escaping gas does not cripple the gas companies' business, at their present prices, but the gas fills the earth, gets into the electrical conduits, and there makes a very bad combination, for which electricity has to stand the whole blame. Indeed, if it were not for the gas, the underground wire problem would be easier, and very much more agreeable. On the other hand, when the electric current wanders off and melts the iron of the gas pipe, electricity again has to stand the blame, and thus there is not a fair distribution of the responsibility.

In order to treat the subject thoroughly, the board of electrical subways, of the City of New York, investigated all the different systems in use in other cities; in connection with the many plans which were submitted for approval to be used in New York.

It was found that in Paris, they are fortunate in having extraordinarily large sewers, through which (in the streets where the sewers run) all of the wires are laid, together with the water pipes. These sewers consist of a large arched passage with a flat floor, through the centre of which runs a deep trench or canal for the sewage. The flat pavement on either side of this forms a broad walk, over which the pipes and wires are suspended from the arched roof. A rail is laid on either side of the canal, and on the track so formed a car can travel carrying a drag which is used in cleaning the canal or sewer proper. In the streets which do not have these sewers the wires are strung upon the housetops.

The only other place which at that time furnished experience at all applicable to the problem here was London. But here there were and are now, practically, no arc lights at all, and therefore no circuits; there are extremely few incandescents, with no out-door circuits; the telephone is not used very extensively, and the wires of the telegraph are placed underground by the government. The plan employed is what might be called the hand-hole "drawing-in" system, and consists of 5-inch cast-iron pipes laid under the sidewalks and accessible through hand-holes or "flush boxes." These pipes are said (I do not know how correctly) to be loosely jointed for the purpose of admitting water to preserve the cables, which are of gutta-percha, the same as is used for submarine cables, and which deteriorate very rapidly when exposed to the air. In other words, they have learned by their experience with ocean cables, how to make insulation which will stand the water, so they try to convert the subway problem into the same kind of work. Conduits have been laid at a later date in other places.

In Brooklyn there are about 10 miles of Dorsett conduit, and about four and a half miles of a conduit consisting of a wooden box made of creosoted boards loosely put together,

with narrower ones slid into grooves on the inside to form partitions. This duct, being loose and unstable, simply affords a means of keeping cables from touching each other and keeping them in place; and as creosote will dissolve rubber it is not a good place in which to put a rubber cable.

Another plan which has seen some slight use in Philadelphia is the Johnstone system. This consists of a broad, flat, cast iron duct, made in sections, about six feet long, and divided horizontally into an upper and a lower half or shell, so that a section can be removed and another substituted without cutting the wires already drawn into place. The duct is divided into a number of smaller ducts, for classifying the wires, by partitions consisting of long slabs of cast iron, which are slid into place in grooves cast in the inside of the outer shell. The feature of this system is the facility which it affords of introducing an outlet from the duct exactly opposite any lamp post or desired part of a building, by taking off the upper or lower half of a single section and putting in its place a new half section with a hole in it at the desired point, to which a branching elbow can be bolted.

This construction has been authorized for a distributing system in New York, on Broadway from 14th to 34th streets, for arc lighting, etc. The work is now being prepared, and the system is, therefore, of some interest.

There goes with this style of conduit a man-hole formed of a bottom, a top, and variable number of rings or sleeves placed upon each other so as to build up the height of the man-hole and permit of the ducts being run out at any depth to escape pipe obstructions, etc. One of these sleeves is split up into a number of panels bolted together, any one of which can be taken off to allow the ducts to be run out on either side at any angle.

All of the other plans by which wires have been put underground, except the Dorsett and other man-hole "drawing-in" systems used in this city, which will be described later, consist of nothing but the wire with covering buried in a trench, and are of no value beyond the taking care of their own particular wire.

Prominent among such plans may be mentioned the Edison tubes. This system, which has been extremely successful for its one kind of service, consists of heavy copper rods wound with rope, and laid in wrought iron pipes filled with an insulating compound composed of Trinidad asphaltum, rosin, paraffine and linseed oil. This compound is run into the pipe when heated to about 300 degrees Fahrenheit, under considerable pressure, while an exhaust is applied to the other end for the purpose of drawing out all air bubbles. The ends of the tubes are then plugged with wood soaked in paraffine, leaving the coppers projecting.

The chief peculiarity of this system of conductors, and the feature which is, perhaps, most familiar to all, is the means of connecting up these lengths of tubing and conductors. The rods are connected by short pieces of copper cable terminating in suitable copper sleeves, which are soldered to the ends of the rods when in position, and the bow-shaped expansion joint so formed is covered with hot compound poured into a small cast-iron coupling box, which is bolted on to the junction. The lines terminate at the street crossing in large cast-iron boxes, like man-holes, where the rods are joined by heavy copper cables to a suitable connecting device near the top.

This plan is too expensive except for very heavy conductors, but serves admirably the requirements of incandescent lighting. In the early days of the system the thin pipes were greatly damaged by picks in digging around them and by outside disturbances. A slight blow from a pick would puncture the pipe, letting in a little water, which was liable in time to form an arc between the conductors, which would in turn burn the compound converting it into a conductor, and forming a cross. The greatest difficulty with these tubes was found to be that the insulator would be converted into carbon by the charring action of leaks at the slightest start.

Tubes of the same style, but containing a large cable of small wires, have been in successful use in carrying telephone wires out from the Twenty-first street exchange in New York.

Another method somewhat similar is the Brooks' system, which consists of wires covered with cotton and drawn through large iron pipes, which are afterwards filled with a heavy rosin oil, so as to prevent the water from entering. This oil is a good insulator.

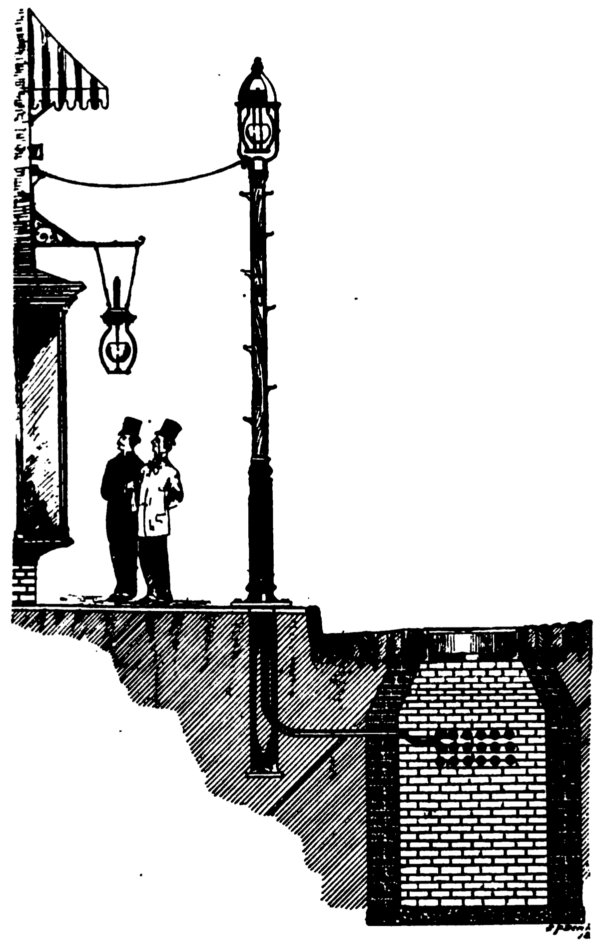


FIG. 2.—Lamp-post Approved by Board of Electrical Control. Manhole and Conduit for Electric Light.

The remaining plans are of a lower grade of mechanical construction, and consist of wires and cables of various kinds laid in troughs and covered with some protecting substance, usually tar or asphaltum.

Among these may be mentioned the few telephone and telegraph wires in Boston, made into a cable laid in a trough and covered with bitumen. A few telephone wires in New York and electric light wires in Pittsburgh are laid in the same way.

There are also innumerable places where cables of various kinds are laid directly in the earth, sometimes with a board covering to protect them from men with shovels. But none of these are of special interest to us, because, obviously, we cannot use them.

The result of the investigations of the commission were summed up in their second report, dated June 30, 1886, as follows:

"The principal systems of electrical subways may be divided, first, as to their material composition, and second, as to their mechanical construction, and the manner in which the wires are placed in them.

"As to material composition, subways are,

"1. Of insulating material, such as wood, glass, concrete, etc.

"2. Of conducting material, such as iron.

"As to mechanical construction, subways are, generally speaking,

"1. Tunnel systems.

"2. 'Drawing-in' systems.

"3. Solid systems.

"4. 'Dropping-in' systems.

"5. Combined systems.

"Tunnel systems, or those where space is provided underground sufficient to allow the passage to and fro of men who place the wires within the subway, could be recommended, were unlimited time and money at the disposal of the commission; but the expense of such a system and the crying need of immediate action preclude the adoption of such a plan. If ever underground railroads become a feature of our city transportation then, perhaps, the tunnel can be used for some of the future trunk line cables.

"In Paris, where the foundations of the city are honeycombed in all directions by large sewers, such a plan is practicable and admirable, but not to be thought of in New York.

"Drawing-in systems, or those where man-holes are provided in the streets, connected by tubes or pipes, through which the wires can be drawn, are next in prominence and convenience to tunnel systems.

"In Chicago there were seen in successful operation nearly twenty miles of conduits of the 'drawing-in and out' pattern of various materials, containing all kinds of wires, as follows:—

"Eight miles of the Dorsett system of concrete conduit divided into ducts, and containing in the separate ducts wires of the city telephone, telegraph and fire service, electric light wires and wires of different telegraph companies.

"Four miles of the Johnstone system of iron conduit divided by metal shelves, and carrying the wires of the Postal Telegraph Co.

"One mile of 3-in. iron pipes, four in number, carrying the wires of the Western Union Telegraph Co.

"Three miles of iron pipes, carrying the wires of the Bankers and Merchants' Telegraph Co.

"In Philadelphia, a comprehensive 'drawing-in' system of iron was seen, containing electric light and telephone and telegraph wires.

"In Boston some two miles of such 'drawing-in' iron systems are in operation.

"In London 9,000 miles of wire are underground, bunched into cables and drawn into 3-inch iron pipes.

"Solid systems, or those where wires are permanently embedded in insulating material and incapable of being reached except by tearing up the streets and the insulation, have been found to work with more or less success. The commissioners saw several miles of this conduit in successful operation in Chicago by the telephone company there, where wires were buried in an asphalt or coal-tar cement, laid in a wooden trough.

"Several miles of similar conduit are in use in Washington for electric lighting, and there are other instances of the successful operation of this description of conduit.

"In this city of New York there are several systems in use underground, each more or less satisfactory to those employing it.

"A prominent example is the Brooks' system, used by the Metropolitan Telephone and Telegraph Co. It consists of an iron tube in which cotton-wrapped wires are drawn, and the tube filled with oil, the oil acting as an insulating medium. It is kept at a desired pressure—the tubes constantly full by means of a stand-pipe. They use a 2½ inch iron pipe, and the system is cheap, costing less than $11 per mile of wire, because into such a pipe they can draw 300 telephone wires. Wires for telephone purposes, and those used in the American District and other call boxes, are of a very light intensity, and do not need as heavy insulation as do all other kinds. This system is claimed to give perfect satisfaction for telephone conductors.

"The Western Union Telegraph Co. has many wires already down in this city, laid in 3-inch iron pipes, into which they draw cables manufactured from okonite or kerite insulation. These pipes are lead jointed, are laid in Broadway, and have man-holes occasionally for taking out the wire.

"To sum up as to the form of subway, and the manner in which the wires are to be placed in it:—

"We are convinced that from the standpoint of an electrician simply, it may be said that almost any plan or system can be *made* to work, from a single lead covered wire laid directly in the earth to a great tunnel upon whose walls the insulated conductors can be hung. Within certain broad limits any system is electrically practicable; retardation and induction can be overcome. It is only when we face in this city the mechanical engineering and chemical questions of interference with water pipes, gas pipes and sewer pipes, of obstructions from vaults, or danger from steam pipes, of the action of sewer and illuminating gas, that the necessity for careful discrimination presents itself.

"In the future, when the uses of electricity become more general, and its nature better known, it may be that the City of New York will absolutely require a grand electrical underground highway, where space can be provided for the conducting and distributing of sufficient power to run all the engines and work all the machinery within the city limits. It may be, and probably will be, that before such space is needed much more will be known of the qualities of different forms of electrical conductors, and of the best method of carrying them underground, and that the matter of electrical subways will be no longer experimental, but practically demonstrated in every detail.

"When such a time comes the commission or other authority will determine what is required to meet the necessities of the occasion.

"The responsibilities of the present commission begin and end with providing for the requirements of their own day, and for such of the exigencies of the future as they can reasonably anticipate.

"Leaving out of consideration all tunnel systems as too expensive, we must also discard any system which calls for the simple laying of insulated cables in the earth. They would not stand the chemical action of the gases and acids; the streets would be continually torn up for new connections and repairs. We are thus shut up to the question of electric subways or conduits, in which the wires or cables, insulated or otherwise, must be placed, and which once laid down should meet all the demands of the present and near future.

"Of conduits it may be safely predicted that, so far as the experience of this and other cities is a test, some form or other of a 'drawing-in' system is most convenient. The life of the best cable is by no means satisfactorily decided, and, of any particular cable, to predict how long it would last would be purely speculative. Of wires not contained in cables it may be said that they are equally or more uncertain in their length of life and usefulness. At all events, for purposes of distribution it is desirable that the wires should be easily approached at frequent intervals, and the commission cannot countenance any plan that looks to the disturbance of pavements more than is absolutely necessary.

"It may be that through lines of wire could be better protected laid in permanent beds of insulating material; but a 'drawing-in' conduit system allows space to be provided for new wires without the frequent tearing up of pavements.

"The commission can, therefore, give their approval to a 'drawing-in' system with frequent man-holes, as the

general form of subway best adapted to meet the requirements of the electrical service of the present."

Up to this time it was the general impression which had not been contradicted by experience, because there was none, that the conduits must be built of a non-conducting substance, and not of metal, because the latter would be liable to chafe through the insulation on the wire and cause a ground, and because the companies using the more delicate currents—particularly the telephone company, declared positively that the presence of the large mass of surrounding metal would interfere by induction with the working of their wires.

The best known plan at this time for building ducts of insulating material, and without the use of metallic tubes, was the Dorsett system, which had been laid to some extent in Chicago.

This consists of a bundle of parallel tubular ducts about two and a half inches in diameter, built of blocks formed of a combination of coal tar, pitch and fine gravel, cast with tubular openings running through them from end to end. These blocks were placed together, end to end, with the holes in line so as to form continuous tubes or passages, and were cemented together by pouring a mastic, softer than was used in making the blocks, into the cracks between them. The blocks were made to adhere to this by warming their ends with hot irons and allowing them to cool after the mastic was poured in. To prevent the melted mastic from closing the ends of the passages, tubular pieces of metal or paper were inserted in the ducts at the ends of the blocks, making a sort of internal sleeve coupling. The conduits so formed terminate in brick man-holes at the street crossings.

The objections to this material, as it was afterwards found, are that it is brittle, porous, requires care in laying, and, having no elasticity, cracks with changes of temperature, so that it is not likely to be made water-tight with average workmanship.

But a conduit was laid in New York according to this plan, on 6th avenue, from 23d to 58th streets, a distance of 1.6 miles. And the objections were then found, as far as arc circuits were concerned, that its numerous joints were liable to open, and it might leak as indicated above.

The next plan proposed for New York was to use a somewhat similar mixture without requiring it to be made so hard, with the object of preventing its cracking, and to preserve the openings or ducts by casting this bituminous mastic, or mixture of bitumen and sand, around long pasteboard tubes. But no tubes could be found which would not absorb moisture, and the heat of the mastic caused the tubes tried to swell up and disintegrate. The manufacturers of indurated fibre wares, were confident that satisfactory tubes could be produced, but it required special machinery and a long time for experiments. Tin and sheet iron linings were then suggested, but objected to, on account of the difficulty of making good joints. Zinc, however, was considered unobjectionable, and an experimental duct of the Averil system, consisting of soldered zinc tubes in bituminous mastic was laid in the yard of one of the manufacturers; but it was found that the heat of the mastic melted the solder of the tubes. This difficulty was met by substituting a lap or fold over-seam, and then it was found that the heat of the mastic also affected the nature of the zinc, impairing its durability. On account of the certainty of the zinc tubing rusting and finally crumbling away, it was next thought best to insure the permanence of the bore of the ducts by substituting for the soft mastic some substance which would set, after being poured in, and become hard and durable. For this purpose a hydraulic cement concrete filling was substituted for the mastic. And then a line was laid in 58th street. In laying, the thin zinc tubing was found very frail, liable to be dented in handling, and therefore undesirable. But it was thought that the concrete would maintain a hard solid, smooth bore, even after the thin sheet metal lining had rusted out.

After a thorough investigation and discussion of all the different materials, and the advantages and disadvantages of each, it was finally concluded that a conduit or subway for electrical conductors, was merely a mechanical protection for the wires to be placed therein and should afford the very best protection possible to be procured, while the electrical protection or insulation might safely be left to the manufacturers of cables and wires to be placed in subways.

It was decided that the use of metallic tubes would not seriously interfere, by induction, with the working of the wires, and were to be preferred because the continuous conducting shield so formed will carry off any escaping current and prevent damage to other cables. Accordingly, conduits of iron gas pipe embedded in concrete were put down, and these seem to be about the best kind so far constructed. They are best, first because there are plenty of workmen who understand gas pipe fitting and laying concrete, and because they are durable and entirely non-combustible. The purpose of the cement is to prevent the iron from rusting, which it does very effectually. If in time the pipes are destroyed by rusting from the inside, the solid hydraulic cement concrete will remain, furnishing a permanent duct with a hard smooth bore.

The man-holes used in connection with these various kinds of ducts have nearly all been built of brick laid in hydraulic cement, and capped with an iron casting to form a seat for the water-tight lid. The lids are bolted down upon a rubber gasket; but, unlike the Edison lids—held by several screws—they are secured by a single thrusting screw, which, passing through a cross-bar presses down upon the centre of the cover. Some of the lids have been made funnel-shaped, so as to cause water to drain away from the edge and collect in the centre. By this means, the liability to leakage at the gasket is diminished, because there is less chance of water standing over the joint. The facility of opening the man-holes afforded by this method of fastening the lid with a single screw, is of great value in reducing the labor and time required to open and close a line of conduit when laying a wire, and is a material advance in the solution of the problem.

In regard to moisture in the conduits: in the iron tube plan which is the best, there is of course no leakage, because the tubes themselves are water-tight, could even be made air-tight, and because they are covered with cement which is in itself water-tight. The man-holes are made of water-tight materials, and there should be no leakage under the lid. Lookers-on find that a great many of the man-holes have a great deal of water standing in them; this is simply because the lids are not fastened down, but simply laid in place by the builders, often without any gasket, and the man-holes fill with rain and stay full until cleaned out for use. When cleaned and closed properly, they appear not to receive any water by leakage. To satisfy myself of this, I had an ordinary brick man-hole, which had been thoroughly cleaned and dried by letting the sunshine in, on a bright day, marked on the inside with lime all the way round under the cover and then closed. This marking was to show whether any water came through the joint of the cover, in which case it would have run down over the lime mark and discolored it, or whether it soaked in through the bottom or sides. But after a rainfall sufficiently heavy to test the leakage, the hole was opened and found perfectly dry and the lime undisturbed. This proved that there was leakage neither through the brickwork nor under the cover.

There is, however, another source of moisture, difficult to overcome, viz.: the condensation of vapor from the air which the man-hole and ducts contain. Every time a hole is opened, it refills itself with warm air, containing more moisture than it can keep when cooled down to the temperature of the masonry; consequently as soon as the

lid is screwed down, this fresh air deposits a dew on the inside of the man-hole. As it is impossible to open and dry out a man-hole without letting in new air which will condense in turn, no amount of cleaning will overcome this difficulty. The presence of moisture tends to corrode exposed wires; and, therefore, the question of whether it is better to protect the splices and make the insulation of the wires so that they will not be injured by this moisture, or to dry out the entire system of conduits by a system of ventilation is unsettled. But this question fortunately is one of minor importance.

The question of distribution of electrical currents from the main subways constructed in the manner I have described, has been largely left by the authorities in the City of New York to the preference of the electrical companies.

Two systems of distribution are at present actually in use in New York by the telephone company. These are known as the house-top system of distribution, an example of which may be seen at Sixth avenue and 51st street, and the hand-hole system of distribution, which may be seen at Broadway and Exchange place.

In addition to these systems, there are five modes of distribution which can be readily applied to the subways as constructed in New York, and which will be allowed in cases where they are severally most expedient,—the lamp-post system of distribution, the house-front system, the house-vault system, now in use in Chicago, the back-yard system, and the man-hole system. In the heart of Chicago, the distribution question is peculiarly easy of solution, because the sidewalks were left hollow by raising the street levels after the great fire, and the wires are run through these spaces to the houses.

Having decided the question of the kind of conduit to use, the commission proceeded to have subways constructed accordingly at once. It was decided best, as a matter of expediency and to prevent accident, that electric light subways should be distinct from those intended for telephone and telegraph service, and it has therefore been the practice of the authorities in New York to build subways for one class of conductors upon one side of the street and reserve the other side for the other class.

The telephone people were the first to realize that underground wires were sure to be, ultimately, a success. Their business had grown enormously, they had about reached the capacity of their poles lines, and it was not easy to get the use of additional streets, because the streets were crowded with wires,—both their own and those of other companies. It was found that the growth of the telephone business was practically put an end to, by the fact that no more room could be found in which to string wires. House owners were charging a rental of one dollar per wire per year, which, in some cases, amounted to a very large rental for a single building, and the telephone people had reached the point of refusing subscribers. They then came forward, and were the first to declare for underground wires.

After some resistance, the telegraph and electric light companies have come to the conclusion that it is as well for them to comply with the demands of the public and place the bulk of their conductors underground. And, as a matter of fact, in the City of New York, to-day, there is but one single company out of the large number doing business here which refuses absolutely to comply with the provisions of the sub-way acts, and nine-tenths of the opposition and outcry has been caused by that company.

At the present time the total construction of single ducts in the City of New York amounts to four hundred and twenty miles. In these subways, there are already in operation some four thousand miles of telephone and telegraph wires, and some hundreds of miles of incandescent electric light conductors. Cables for arc lighting are to be drawn in on Broadway from 14th to 34th streets, by the Brush Electric Lighting Co. within the present week. A letter from the electrician of the Metropolitan Telephone and Telegraph Co., bearing date August 25th, as estimating the length of cables of various kinds now underground, is as follows:—

New York, August 25th, 1888.

S. S. Wheeler, Esq.,
Electrician of the Board of Electrical Control.

Dear Sir:—I have hastily collected the following information relating to the underground mileage of wire:—

The number of miles of single wire conductors in New York city of the various kinds is as follows:—

Brooks' system, laid May 28th, 1885	200 miles
Patterson cable, laid March 18th, 1885	226 "
Edison system, laid June 20th, 1885	194 "
Patterson cable, laid in 1886-87	805 "
Patterson cable, twisted in pairs, number of miles counting both wires, in 1888	2,272 "

We have in course of construction some 12,000 miles of conductors which will be laid in September and October.

Total number of miles already laid in New York, 3,697.

The number of miles of underground wire in Brooklyn is 2,100. The number of miles of underground wire in Paris is 4,100. The number of miles of underground wire in Chicago is 200.

As per report of telephone convention held September 26th, 1887.

The number of miles of underground wire in Boston is 400. The number of miles of underground wire in Pittsburgh is about 1,000.

I find that there is a very small amount of underground wires used in London for telephone purposes, there being some short lengths used entering exchanges, which is not worth while considering. Respectfully,

(Signed) J. A. Seely, Electrician.

It will be seen from this that there are already underground in the City of New York more electrical conductors than in any other city in the world (except Paris), while the capacity of the construction already finished in this city may be estimated fairly at something over thirty thousand miles of conductors.

There are through lines completed from the Battery to the Park on the two principal thoroughfares of this city, Broadway and Sixth avenue, and a gradual conversion of overhead lines to underground lines in the busy parts of the city may be confidently expected.

The board of electrical control is not unmindful, however, of the magnitude of the labor and expense required in converting the present arrangements into underground systems, and does not contemplate either the hampering of the business of electrical companies by forcing unreasonable numbers of wires underground, or by attempting to compel the use of subways faster than is consistent with the efficiency of the various electric service to the public. If the great mass of overhead conductors are removed, and the remainder of the service brought to a condition which will insure the safety of the public, and, at the same time, the benefit of the companies themselves, it will be the result desired by the people of the city, and which the board of electrical control is endeavoring to attain.

As to this matter of regulating the overhead service in the city, I may say that an investigation of all the wires overhead, instituted since I have been connected with the work of the authorities in charge of electrical matters here, by the inspectors appointed after a rigid examination and found competent for the purpose, has shown that a great deal of very bad and unnecessarily dangerous work has been done in New York, and that a reprehensible and inexcusable condition of overhead wires is the principal, if not the only, cause of the clamor for underground service.

In addition to this, an enormous quantity of wire and a large number of poles not in use at all exist, amounting, as

has been variously estimated, to from a half to two-thirds of all the wire and poles in the city.

As I have said, a system of inspection and reports has been organized, and within a few months there have been found and reported to the owners 2,000 dead wires and other objectionable things described in the enclosed schedule, which explains itself. A notice is sent out in every case; at the end of a week the work is again inspected, and if nothing has been done the owner is again notified, and if the wires, poles, etc., are not necessary, a notice is also sent to the Bureau of Encumbrances of the Department of Public Works to remove them.

All arc lamps that are so low as to be within the reach of a pedestrian with an umbrella are reported as too low. Circuits which have especially defective insulation or joints are reported as dangerous. A few cases of bad indoor work have been reported as violating the rules of the board of fire underwriters, and so on. The number of complaints sent to the various companies, as well as the proportion of them that receive attention by each company, are shown in the detailed schedule, which indicates the position taken toward the work of inspection by the several companies, and I may say that the contumacious company of which I have already spoken, is the only one which disregards the notification of flagrant bad work, for which there is no excuse, and which everyone else admits should be inspected on behalf of the public and corrected immediately.

One has no idea of the aerial freebooting that is and always has been going on with overhead wires, until he spends some time seeing what there is overhead. The condition of wires in this city is simply outrageous. Every other kind of business, such as those which involve obstructing the sidewalks, have fallen under the supervision of some branch of the government, and cleanliness and order have been insisted upon; but heretofore there has never been any supervision of out-door wiring, and its condition corresponds to that of a city without police supervision.

The companies owning wires will not permit each other to make common use of the poles, but will chop off wires owned by others without notice. The telephone people object to the electric light wires on account of the induction. Where there is a line of light wires on their side of the street passing close to their poles they will not allow them to be made fast. The result of the necessity thus made for extra poles is sometimes four lines of poles on one side of the street, hence most of the wires swing close to or against the other poles to which they are not attached, and linemen in climbing them have to crawl through all the other wires which are not fastened to cross-arms.

Among the cases of dangerous wires and unnecessary obstructions found by the inspectors, are full lines of large poles extending over miles of streets, filled with wires which are "open" and out of use, but left standing to save the expense of removal; long lines of poles left standing to preserve right of way; arc light day circuits within reach and with the insulation dropping off, and bunches of dead wires hanging from house tops, etc.

All of the work of inspection done by this department is such as is necessary for improving the condition of overhead electrical work and removing fixtures, etc., that are absolutely dangerous and objectionable.

For the purpose of the various legal proceedings which are being carried on to compel the most objectionable arc light company to make a start in placing their wires underground, the other principal companies having proceeded voluntarily, the pole line on 25th street from Broadway to Fifth avenue was chosen for special complaint. The subways on this route which were specially provided for these lines have been finished for some time, and are dry and in good order. This line of overhead wires is in bad order, one of its stretches having no less than thirteen splices; and it is made still more liable to do damage by the presence of numerous dead wires which, not being required for use, are practically stored upon the cross-arms.

REPORT OF ELECTRICAL EXPERT OF THE BOARD OF ELECTRICAL CONTROL.—DETAIL OF ALL NOTICES OF VIOLATIONS OF RULES AND REGULATIONS SENT, FROM JUNE 14 TO AUGUST 24, 1888.

Name of Company and nature of violation.	No. of violations.	Notices sent.	2d notice.	Notice answered.	Notice attended to.	Notice sent to Bureau of Incumbrances.	Notices. Referred to board.
U. S. Illuminating Co.							
Dead poles.	113	38	10	2	...	4	...
Dead wires.	283	173	52	29	20	46	...
Useless fixtures and wires.	28	26	11	6	...	1	2
Lamps low.	28	26	11	2	2	...	1
Wires not insulated.	60	53	2	17	25	...	...
Dangerous poles.	1	1	...	...	...	...	...
Total....	513	317	86	56	47	51	3
Brush Electric Lighting Co.							
Dead poles.	42	14	2	1	4	4	...
Dead wires.	34	27	3	16	11	3	...
Wires not insulated.	30	29	10	6	12	...	...
Dangerous circuits.	3	3	...	3	3	...	...
Slack wires.	1	1	...	...	...	...	...
Total	110	74	15	26	29	7	...
Metropolitan Teleph. & Teleg. Co.							
Dead wires.	60	41	5	19	27	...	...
Dangerous poles.	1	1	...	...	...	...	...
Total....	61	42	5	19	27	...	...
Fire Department.							
Dead wires.	43	23	2	...	...	...	...
Dead poles.	2	2	...	...	...	...	...
Dangerous poles.	2	2	...	...	...	...	...
Other violations.	2	2	...	...	...	...	...
Total....	49	29	2	...	...	...	...
West. Union Telegraph Co.							
Dead wires.	69	41	3	2	13	2	...
Dead poles.	6	5	...	...	1	...	...
Slack wires.	1	1	...	...	...	...	...
Total....	76	47	3	2	14	2	...
Mount Morris Electric Light Co.							
Lamps low.	8	8	...	8	...	1	8
Total....	8	8	...	8	...	1	8
East River Electric Light Co.							
Dead wires.	13	11	...	...	...	...	...
Lamps low.	2	2	...	...	...	...	...
Total....	15	13	...	...	...	...	...
Daft Motor Power Co.							
Dangerous circuit.	1	1	...	...	...	...	...
Other violations.	1	1	...	...	...	...	...
Total	2	2	...	...	...	...	...
Postal Telegraph Co.							
Dead wires.	3		...	...	...	...	...
Dangerous poles.	1	1	...	...	1	...	...
Total....	4	1	...	...	1	..	...
American Dist. Telegraph Co.							
Dead wires.	14	8	1	...	2	...	...
Dangerous circuits.	2	2	...	...	...	...	...
Total....	16	10	1	...	2	...	...
Police Department.							
Dead wires.	15	4	...	...	...	...	...
Dead poles.	8	2	...	...	...	...	...
Total....	23	6	...	...	..	...	...
Grand total....	867	548	112	111	121	61	11

Notices sent to companies, as above....	548
Notices sent to Bureau of Incumbrances, as above.	61
Notices sent to Bureau of Incumbrances of poles, and wires for which no owners could be found....	131
	740

In conclusion, we may sum up the situation about as follows:—

The telegraph and telephone problem is practically

solved. It is found necessary to resort to subways in order to get sufficient space for wires, and wires for this use are being drawn into the tubes as fast as the labor can be performed. There are about 4,000 miles of telephone and telegraph wire already underground, and 12,000 miles of cables about to be laid in the fall. It is estimated that the saving in cost of maintenance will be about $100,000 per year owing to the permanence of the kind of work which is possible underground.

The laying of electric light wires has not been so fully developed, and naturally none of the companies care to bear the expense of the first experiment. But after the initiative has been taken the difficulties will be overcome as they arise, as in the development of all other enterprises, and the underground system will become a settled and accepted fact.

Meanwhile, the lawless running of overhead wires is being stopped. All wires in a street must be run on a single line of poles. The dead wires and poles must not be stored in the streets, and all construction must be made under the supervision and control of some official in precisely the same way that other works which affect the public are carried on.

The President—If any gentleman wishes to ask Mr. Wheeler any questions on the subject he has discussed in his paper, it might be well to put them now before they slip from mind.

Mr. E. T. Lynch, Jr., New York—I would like to ask Mr. Wheeler the estimated cost of laying these conduits.

Dr. Wheeler—I am not very well prepared to give the cost, but if Mr. Leslie, the manager of the construction company, who is present, will do so, I think he can probably answer Mr. Lynch's inquiry.

Mr. E. A. Leslie, New York—I do not think it will be possible to give an intelligent reply to that question, because the cost of construction varies very much, as the circumstances vary. In some cases the engineering difficulties are easily overcome, while in other cases they are very difficult indeed. Then again, the character of the excavation has a very great deal to do with it. It is a hard matter to say what the cost would be, unless the number of conduits and the side conduits, and so on, are specified.

Mr. Morris—Dr. Wheeler spoke of there being 9,000 miles of underground wires in the City of London. I would like to ask him whether those are high tension wires, and also as to what was the efficiency of the service.

Dr. Wheeler—I have stated already in the paper that there were practically no high tension currents in London, and that the wires put underground were put there by the government.

Mr. Lynch—Dr. Wheeler stated also that there was a conduit in 25th street. I would like to know if any means have been devised for getting the wires from the poles into those conduits, or whether any supplementary conduits have been provided by which the wires could be run to customers living in the block.

Dr. Wheeler—I also stated that the Johnstone company's conduit had been authorized as a distributing system to be laid on Broadway, and that it could be used in 25th street, but that the choice of a distributing system was left to the companies, and if they could find a better system why, of course, they could use it. It does not seem to me very difficult to get wires from a man-hole to a pole There are several hundred of them at the corner of 23d street and Broadway—telephone wires, coming up in tubes from the man-hole and going out on the poles. The same thing exactly can be done with the electric light wires. The question that is most difficult to answer is how to distribute them cheaply to each house; not how to get them out of a man-hole.

Mr. Lynch—Can the gentleman tell me if any practical trial has ever been made of the Johnstone system for electric lighting wires?

Dr. Wheeler—I am not informed as to that. I understood Mr. Johnstone was to be here himself.

Mr. DeCamp—I will say in regard to the Johnstone conduits—I presume these are the same that are used in Philadelphia—that it is a very good form of conduit. It is expensive, but I believe it is perhaps the best conduit we have. I am free to say, at any rate, that it is the best form of conduit that has ever been brought to my attention; but we have never got anything to put into it yet that answers the purpose.

Mr. Lynch—As I understand it, the subway company which lays down the conduit charges a rental for its use, and the company whose wires are to be put into it are supposed to make an arrangement with the subway company to put down supplemental conduits and connect the wires therein. Now I want to find out if the electric light companies are responsible for all work of that kind—if they are directly responsible for the wires and the supplementary conduits?

Dr. Wheeler—I think that question had better be referred to Mr. Leslie, who represents the conduit company.

Mr. Leslie—I do not see wherein the question of responsibility is important in the question of the practicability of operating electric light current. I will say that the company that Mr. Lynch represents has been furnished with information on all those points.

Mr. Lynch—I do not appear here as representing any company. My connection with the U. S. Illuminating Co. was broken off some time ago. I appear here asking for information as a member of this association. Now, as I understand it, the subway commissioners say: Here is a system which we think the electric light companies should put down and should be responsible for, besides paying for it.

Mr. Leslie—I believe Mr. Wheeler represents the subway commissioners. You had better ask him that question.

The President—Gentlemen, this is getting off from the main point, and we are getting into the general topic. The chair will have to stop this discussion at this point and ask these gentlemen to be present this afternoon, because it is very evident there are going to be several questions that will have to be answered.

We will now take up the next paper.

Mr. E. G. Acheson then read the following paper:—

DISRUPTIVE DISCHARGES AND THEIR RELATION TO UNDERGROUND CABLES.

BY E. G. ACHESON.

From among the numerous problems that are earnestly calling for solutions before perfection can be claimed in underground systems of electrical distribution for arc lighting, I selected, as the one presenting probably the greatest importance, and, consequently, the one most desirable to solve; *the determination of the cause and cure of the frequent puncturing of the insulation, especially at the terminals, of lead encased conductors, when carrying high potential currents.*

In a communication to the electrical press, published July 7th, 1888, under the title "The Influence of the Condenser on Disruptive Discharges," a detailed description of a series of experiments on the discharge between points in air was given; they having been made with varying E. M. F's. and condenser capacities.

These experiments resulted in the formulation of the general law expressed in the equation,

$$\frac{(\text{E. M. F.})^2 \text{ charge in coulombs}}{a} = d$$

or

$$\frac{(\text{E. M. F.})^3 \text{ capacity}}{a} = d$$

where a is a constant for the dielectric and d is the spark length; the charge being expressed in coulombs and the capacity in farads. In the same article the value of a was taken as 135 and d was expressed in inches.

While these experiments may serve as a basis or foundation to build upon, much more must be known before they will meet the requirements of the engineer operating with high potential currents, and with the object in view of obtaining, at least a small portion of this required information, my experiments were extended into the more practical part of the subject, and furnished the results I have embodied in this paper.

The most probable condition of a discharge in a cable would be between the cylindrical conductor and a point or projection on the lead covering, hence the first point to determine was the striking distance between such a cylindrical body and a projection or point.

Experiments were made with a point and the side of a wire, two sizes of the latter being used, a No. 8 and a No. 16 B. & S. wire gauge. There was no difference between the results obtained with the two sizes. The length of the spark was found to be about 55 per cent. when compared with that produced between points with the same E. M. F. and capacity.

This difference gives a new value for the constant a, which is found to be 263.

The equation for a spark length between a point and a cylinder will, therefore, be,

$$\frac{(\text{E. M. F.})^2 \text{ capacity}}{263} = d \text{ in inches.}$$

The following approximate values of a have been determined, for the conditions and dielectric specified, d being expressed in inches.

Dielectric.	Spark between.	a.
Air.	Points.	135
Air.	Point and wire.	263
Paraffine and cotton.	Point and wire.	5,822
Ozite and cotton.	Point and wire.	7,759

The conditions governing the possible disruptive discharge, through the insulation of the lead-covered, grounded cable, are so numerous that it would be quite impossible to exhaustively consider them, even if the necessary data were at hand, within the limits of this paper. It will therefore, be necessary to confine the subject to the more important conditions, and the exposition of the law by means of a case that might be found in practical work.

In figure 1′, is illustrated a portion of an arc light circuit, consisting of the dynamo D, and 30 lamps, L, connected in series by a lead covered underground cable. For the purpose of illustration and calculation, it is assumed that the lamps are separated a uniform distance of 300 feet; the size of the conductor, a No. 4 B. & S. wire gauge, insulated with one-tenth of an inch of cotton and paraffine; the capacity per mile is 0.704 of a microfarad, and the E. M. F. at the brushes of the dynamo 1,500 volts. Also, as an assistance in calculation, it is supposed that the drop in the E. M. F. occurs in the lamps only.

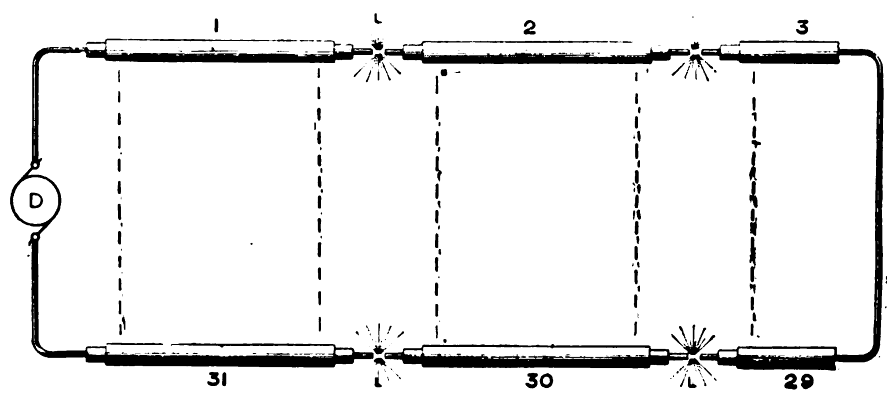


FIGURE 1

The capacity of each one of the 31 sections of cable separating the lamps and dynamo, and which are numbered in regular order from 1 to 31, will be 0.04 of a microfarad, and the capacity of each division, from conductor to conductor across the circuit, as between sections 2–30 will be,

$$\frac{.04 \times .04}{.04 + .04} = .02 \text{ microfarad}$$

or in this case one-half that of one side.

With these conditions each division, composed of the paired sections as 1–31, 2–30, 3–29, and so on, will have a potential tending to break through the insulation to the lead and thence across the intervening medium in the direction of the broken lines, of a value of 1,500 volts at 1–31 and decreasing by 100 volts for each succeeding division.

These various potentials, will, provided the insulation is perfect and the leads well grounded, induce a static charge between the conductor and the lead of each section, of a value measured by the potential across the division, and the specific inductive capacity and thickness of the insulating material.

In the case under consideration, the thickness of the insulation and the specific inductive capacity are such as to induce a condenser capacity of .02 of a microfarad, and with an E. M. F. of 1,400 volts as would exist between 2–30, the discharge would be, 1,400 × .02 microfarad = .000028 of a coulomb; and if the conductors forming the two sides of this division, should while in this charged state be insulated from each other, as might be done by breaking the electrical continuity at both ends of either one of the sides, the energy stored within it would be able to produce a disruptive charge through air, from the conductors to a point, or *vice versa*, equal to

$$\frac{(1{,}400)^2 \; .000028}{263} = .2087 \text{ inch.}$$

This is almost two and a tenth times the thickness of the insulation; but the thickness of cotton and paraffine, composing the insulation of the cable, that this energy would pierce, would be:

$$\frac{(1{,}400)^2 \; .000028}{5{,}822} = .0094 \text{ inch,}$$

or less than one-tenth of the thickness of the insulation.

Two questions now present themselves: First, are the sides of division 2–30, or any of the others, liable to become insulated from each other, or attain a condition favorable for a discharge, for will there not always be a path open for discharge around the circuit, either by way of the lamps or the dynamo? The second question may be stated thus: Is it probable, with the conditions of the case above taken, that the insulation will ever be pierced, seeing that the discharge through the insulating medium cannot be greater than .0094 of an inch, whereas the thickness of the insulation is 0.1 of an inch?

It is evident that from accidental causes, such as the breaking of the circuit at two points, it is possible to have the two sides of the division, insulated from each other; but such accidents are not liable to occur, especially when it is remembered that the breaks would have to be made simultaneously. To make the probability of this action occurring worthy of consideration, other means of producing it must be looked for and found.

On a circuit using coils shunted around the arc, the electrical continuity is established at each end of the two sides of the division, by one of these coils and the arc.

From the experiments of various experimenters, prominent among whom may be mentioned Professor Hughes and Dr. Oliver Lodge, it is concluded that the self-induction in these coils would be of such a value as to offer an almost insurmountable barrier to the flow of the charge through them; and this being the case, the discharge if it occurs at all must be through either the arc or the insulation of the cable. To determine whether the charge would pass off through the arc, the apparatus shown in figure 2, was used. Twenty incandescent lamps, L, of 100 volts each were connected in series to the lines M, N; in the line N, was placed the switch S, and the contact points 1 and 2, the former being mounted in the revolving post P, thereby permitting of the points being opened; the condenser K,

was connected across the circuit from the line M, to a point, 3, between the switch and the contact points, on the line N; around the condenser were placed the points 4 and 5, with suitable means of regulating the distance between them. M and N were connected to the two sides of a transformer supplying an E. M. F. of 2,067 volts. The points 1 and 2 being in contact no amount of rupturing of the circuit at S, and adjusting of the space separating 4 and 5, would cause a discharge to occur between them; but upon opening the points 1 and 2, and thus establishing an arc in the circuit, the opening of the switch S, would cause a heavy discharge between 4 and 5.

From this experiment and Dr. Lodge's results with circuits containing self-induction, the conclusion must be drawn, that conditions favorable to a disruptive discharge are exceedingly likely to occur, that upon opening an arc light circuit the various sections of the cable become, so far as the static charge is concerned, insulated from each other.

In considering the second question the fact is at once recognized, that where the constant *a* for the dielectic surrounding the conductor is that of the cotton and the paraffine a disruptive discharge would, under the circumstances cited, be impossible; and the answering of the question in the affirmative will therefore turn upon the probable lowering of the value of *a*.

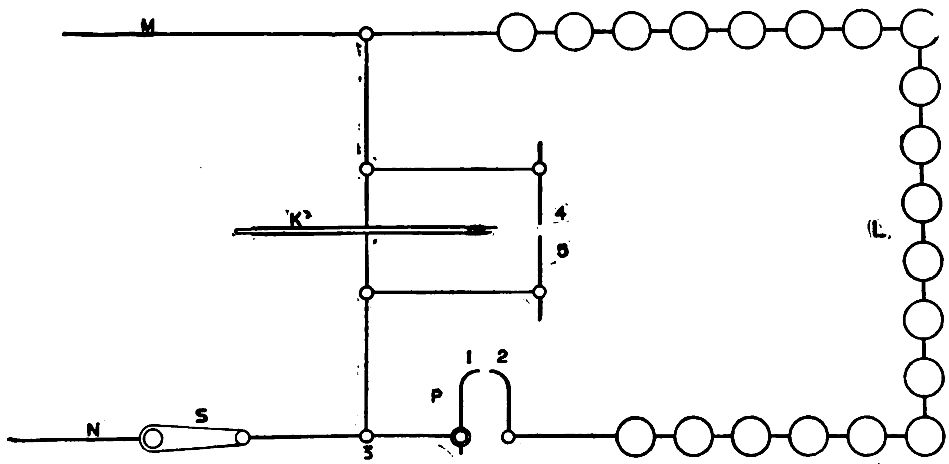


FIGURE 2

Any one familiar with insulations as applied to conductors, knows that all of them, with the exception of rubber and gutta-percha and their compounds, will permit water or moisture to penetrate them, and as the hydro-carbons and water do not form chemical compounds, the one being insoluble in the other, this passage of the water must be a purely mechanical action, and furthermore, openings, cracks, or crevices must exist in order to permit of its passage. In many cases the cracks are visible to the eye, while in others they can only be detected by submerging the insulated conductor in water for a time and then testing electrically. But even after proving the existence of these cracks, it remains to be determined that the static charge will be influenced by them.

As one means of testing the case, a plate of glass .072 of an inch thick was broken into two pieces and the two parts immediately fitted into their former positions and held together by clamps. The crevice or space separating the parts, was infinitesimal in width, as will be evident to anyone who may have made a similar experiment. The restored plate was placed between two discharge points, in such a position that the line joining the points passed through solid glass. Under these conditions I was not able with my facilities to cause a disruptive discharge to take place through the plate; but on moving it so that the line joining the points would lay in the plane of the fracture, a disruptive discharge occurred with an E. M. F. of 2,067 volts and a capacity in the circuit of .003.22 of a microfarad.

While this demonstrates the minuteness of the path required for a discharge, it is hardly a parallel case to what would exist in an insulated conductor, where the insulation was built up out of many overlapping windings of fibrous material and then treated with an insulating compound, for in this case the cracks or crevices produced by temperature variations and the bending incident to handling and laying of the conductors will not be direct lines or planes from the conductor to the metallic casing, but angle or zigzag lines, following the interstices of the fibrous structure; this difference would result in the lengthening of the path of discharge, but, scarcely to an extent sufficient to raise the resistance to discharge to the value of the insulating material in a perfect state; and so long as the value is below that of the insulating material, the value of the constant *a* is also lowered, and it is, therefore, reasonable to assume that the conditions may become such as to warrant an affirmative answer to the second question.

Unfortunately both of the two grand divisions of conductor insulators, the fibrous and non fibrous, have their faults, for while the fibrous has the, in some circumstances, serious fault of cracking, the non-fibrous has the even greater fault of losing its insulating qualities and running off the conductor, when heated, as might occur by an accidental overloading of a circuit; and when it is confined, as in a lead covering, it permits the conductor to become decentralized, and eventually come in contact with the lead casing. Between the two insulators, with the faults specified, inseparably associated with them, there would, for high potential currents, be little or no choice, but fortunately means have been devised whereby the existence of the cracks or crevices in the fibrous insulating envelops, when properly protected from water by a metallic casing, is immaterial, as they are sheared of the power of diverting the discharge into the paths opened by them.

These ends are accomplished by the simple expedient of causing the discharge to occur at such a place and in such a manner as not to pass through the insulating envelop.

This may be done in a great variety of ways; but the most simple one that has suggested itself to me is shown in figure 3, where A is the lead covering; I the insulation; C the conductor; and P a wire connected to A and extending out beyond I, its end, K, being adjusted in relation to C so as to leave an air space slightly less than the thickness of the insulating material I. Under these conditions when a discharge occurs it will invariably be at K and not through I.

While this simple arrangement illustrates the action and

answers as a means of protection, it is evident that some device more durable and capable of adjustment would be preferable. A design meeting these requirements is shown in figure 4.

In the figure, A is the lead covering; I, the insulation, and C, the conductor. Mounted on the lead A, and held in place by the band V, is the metallic arm P, carrying at its outer end the pointed rod R. Another pointed rod R′ is held by a projection on the ring B, which is mounted on the insulating brushing D. A fusible wire, F′, connects the ring B to the metallic sleeve or collar E. The distance between the points R and R′ can be adjusted, and the rods held in position by suitable screws.

It is evident that the operation would be similar to that of the device shown in figure 3. The electrical potential between the conductor C and the lead covering A, before attaining a height sufficient to discharge through the insulation I, will discharge across the air space between the rods R and R′, for these rods being in electrical connection with A and C, will attain their potentials; and the points of the rods will, according to known law, have an electrical density above that of A and C, or that requisite to produce a discharge across the intervening air. The fusible wire F, is inserted as protection against injury to dynamos and cables in case of a ground existing on the other side of the circuit.

There are several points, apparently trivial, but really of much importance, relating to the design and material of construction of a device for discharging a cable.

The distance, measured on the exposed surface, separating the points of support of the discharging arms or rods, should be as great as possible, as there would be a loss of energy, across this space, in case the distance was small and dampness existed. Another point to remember is, that the constant a, should have a known value, and, therefore, the most appropriate design for the discharger is one employing points to discharge from and an unvarying intervening medium, such as air.

In order to obtain some definite information on the question raised by Mr. Leggett at the Pittsburgh meeting, as to the effect on the insulation, of a short bend or indentation in the lead of a cable, I caused a very deep dent to be made in a cable, so deep in fact that it would at once have been condemned in practical work, and then connecting it into the working circuit, an attempt was made to cause a disruptive discharge to pass through the compressed insulation at the point of indentation, but the attempt was unsuccessful, the discharge preferring to occur at any other point.

Another experiment was made to determine the effect of bending the cable backwards and forwards several times in the same place. A length was selected in which the discharge always occurred at either one of the ends, and after the bending operation had been performed a number of times, I was able to produce the discharge through the bent portion in preference to the terminals.

These tests show the superior strength of the insulation in the more condensed or homogeneous forms, and the weakening effect of much bending.

In this connection it may be well to inquire more fully into the tendency of the discharge to occur at the terminals of the lead. It is a well-known fact that the greater number of the grounds or burn-outs that occur on arc light circuits are at the terminals of the lead, or at the joints, and it is precisely at these points that the charge, acting under well established and familiar laws, would be most dense, and owing to the presence of the edges or points for the electricity to flow from, the disruptive discharge will, under ordinary circumstances, take place between the edges or points, and the conductor within the insulation. Owing to the special facilities offered at these places, for the passage of the discharge, it is probable that in many cases, burn-outs occur under the influence of a charge that would be unable to produce a discharge through the continuous portions of the cable.

In order to reduce the probability of a discharge occuring at terminals and joints, I would suggest that the lead whenever cut be made bell shape, in order that all edges or points be turned away from the conductor.

It may be appropriate at this point to consider briefly, that vexed question,—"Which way does the spark pass?"

There is a relic of the past ages still existing, to a greater or less extent, among those who are unfamiliar with the present state of electrical science, and which I have no doubt many, if not all, of you have heard. The favorite way of expressing it is thus: "*The earth is the home of electricity and it is continually striving to get there by the quickest and shortest route.*"

By this theory the electricity as represented by the spark would always jump from the conductor to the lead and thence pass to the earth.

It is plain to see the great weight this would have in an argument against the near approach of the conductor to the earth, as is necessitated in the underground system of distribution.

The direction of the discharge is determined by the form or figure of the charged bodies and the characters or signs

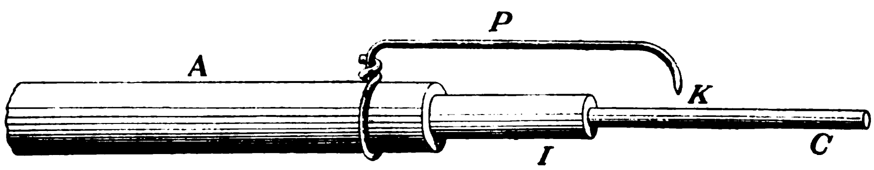


FIGURE 3

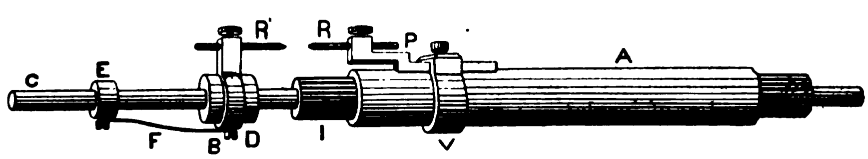


FIGURE 4

of the charges on them, the earth playing no part, other than that of a conducting medium.

On an underground system there is, the moment before a disruptive discharge occurs, an unstable equilibrium between two points of the system or rather of the conductors forming the system and the insulations or dialectrics separating them. Through the line joining the points there is a strain produced by the difference of potential of the points, the tendency being to a neutralization of the potential differences. Against this strain is opposed the resisting power of the dielectric intervening (and usually consisting of the insulations on the conductors and the earth which separates them). The disruptive discharge that follows, may be either from a conductor to the earth or the reverse, but in neither case is there the slightest quantity of electricity left in the earth as a result of the discharge. It is a transmission of energy from one point of the system to another of a different potential, and the amount of electrical energy lost in the passage is expended in overcoming the resistance, and appears as heat.

From the experiments and conclusions of Faraday, I have made the following deductions.

1. When the charged bodies are of the same size and form, the *spark discharge*, will, other things being equal, be *from* the positively charged body.

2. Other things being equal, less potential is required to produce a *brush discharge* than a *spark discharge*, and when it does occur it will be from the negatively charged surface.

3. In all cases where the charge of electricity is on, or closely associated with the discharging surfaces, a diminution of either surface will facilitate a discharge, and when any considerable difference exists in their areas, the discharge will always be *from* the smaller surface.

4. A spark from a small body to a large one will be from 8 to 10 times greater in length, when the small body is charged positively, than it would be with a negative charge.

In general, the direction of the discharge between the conductor and the lead, through the insulation, is subject to the form of the surfaces of the conducting bodies; a slight burr or point on either one being sufficient to determine the direction of the spark.

In a series of very interesting articles by Mr. G. L. Addenbrooke in the London *Electrical Review*, the subject of spark length disruptive discharges and the advantages of a perfectly continuous and unbroken dialectric are extensively treated. The influence of the capacity of the cable is, however, entirely neglected. Special stress is laid upon the advantages of a continuous envelop of insulation; and those using rubber covered conductors are particularly cautioned against handling or bending them when the temperature is lower than 45 degrees Fahr., as fissures or cracks are then liable to occur and permit of the passage of discharges.

This, I confess, was information to me and puts a certain limitation to the qualities I have given above to rubber. and which was written before this statement of Mr. Addenbrooke's came into my hands.

As the experiments referred to in this paper have extended over a considerable period (not less than six months), there have naturally been a considerable number of questions and points presented from outside sources. Others have been led into the field to experiment, and with the equally natural result of obtaining in some cases effects that they have construed to be at variance with those I have secured. I have one case in mind where the experimenters found it impossible to produce a disruptive discharge so long as the lead of the cable was insulated from the ground, but the grounding of it made the production of the discharge feasible, and they concluded that the theory of a disruptive discharge was not correct. This is a repetition, under different conditions, of the very old experiment of attempting to charge a Leyden jar with the jar insulated. The first condition to be arrived at in the charging of a jar is the grounding of one of the surfaces.

A disruptive discharge through the insulation of the cable, cannot occur without a charge being first formed, hence it is absolutely necessary that a ground be made to the lead.

The resistance of the ground connection to the lead is, to a very great extent, immaterial, as the charge is cumulative, and the energy expended in the discharge is only that held in the charge; hence though the ground resistance may be many megohms in value, and the charging process extend through a considerable time, there will eventually be a storage of energy on the surface of a value sufficient to rupture the insulation at the first change in the charging current.

The spark discharge is all but instantaneous in its action, and with the work restricted to this immeasurably short space of time it is necessary to have the energy on hand, as it were; there is no time to generate it, electrically, at the dynamo and convey it over long or even short distances.

The subject of disruptive discharges with various resistances and self-induction placed in the path of energy, is beautifully treated in a paper read by Dr. Oliver Lodge, before the Society of Arts, April 17.

One word more before closing this subject. It is safe to predict, that the disruptive discharge being provided for, little or nothing more would be heard of the much talked of pin holes in the lead, and the moisture absorbing terminals; the undergrounding of arc light cables would become a thing of certainty, and our municipal governments relieved of a great bug-a-boo.

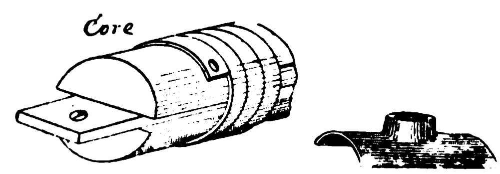
Mr. Acheson was followed by Mr. A. C. Chenoweth, who read the following paper:—

DESCRIPTION OF AN UNDERGROUND CONDUIT.

BY ALEX. CRAWFORD CHENOWETH, C. E.

The changing of electric light conductors to an underground system having engaged the attention of this meeting, I will place before you a method of constructing ducts that can be so arranged as to meet many of the objections heretofore presented.

The object of this paper is not for the purpose of discussing the merits or demerits of systems that have already



FIGS. 1 AND 2.

been presented, but to invite your criticism of the practical points of the method I am about to describe.

Let us assume that the subject of insulation has been settled, and that an arrangement of conductors in a structure permanently located, is so contrived that demands from time to time for an increase in numbers can be met at a small cost. This being done in order to meet the financial question. The material from which to build these structures must withstand the forces of nature that are brought into action in their new relations. Concrete, a mixture of Portland cement and sand in suitable proportions, well incorporated, answers all the requirements.

The form of the structure requires a system consisting of ducts 4″ in diameter, with large man-holes located at convenient points for purposes well established in previous discussions, with other entrances to the ducts, through openings located at intervals, to be used when required as connecting points to houses and stores. All parts should be

constructed with smooth interior, free from joints, faults, depressions, and water tight.

The structure is formed by means of a core which consists of a wooden cylindrical rod, made in lengths of 14 feet or 20 feet, which is cut in two, forming two half cylinders. The space removed by sawing through the rods, when the halves are placed together, is occupied by an iron rod, having a thickness equal to the portion removed by saw, restoring the cylindrical shape; this forms the mandrel or core shown (figures 1 and 2).

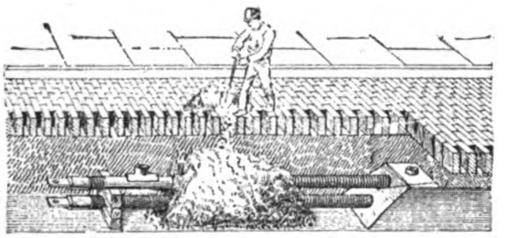


FIG. 3.—Chenoweth Conduit.

Now, a ribbon of galvanized iron, one inch wide, and of a thickness equal to 27 gauge, is wound spirally around the mandrel of wood, from end to end, securing the ends with a fastener to the wood, to prevent unwinding. The outside of core is now painted with a mixture of clay, powdered soap stone and water.

The core thus described is ready for use. A ditch is prepared, the core is placed in it, resting on cross-pieces of wood; if more than one duct is to be constructed, other cores are ranged side by side. The concrete in a plastic state is now tamped well around, bringing the top to an even level. The iron rod is now removed, as well as the pieces of wood on which the ends of core were resting, also the fastenings of the ribbon ends. The wooden half cylinders are now drawn out, leaving the spiral casing, which remains for several days.

A new core is inserted in the end of the spiral, the ribbon of old core is fastened to ribbon of new core by a swivel, and you proceed in same manner as before, thus constructing several hundred feet with the casing remaining in. When the cement hardens the casing can be drawn out, being a spiral; this being done at any man-hole or unfinished portion of the work. As the spiral ribbon is removed, the surface coating of clay and soapstone adheres to the interior of the duct, producing a smooth surface, and acting as a lubricant to reduce friction, when conductors are drawn in, preserving the insulation. This construction insures a monolithic structure, smooth interior,

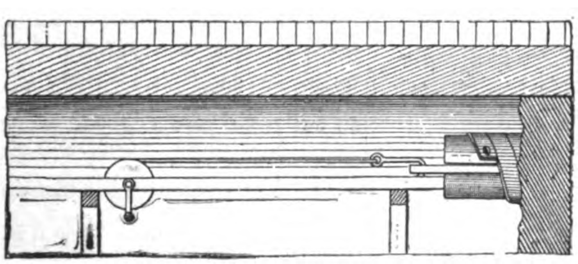


FIG. 4.

straight, free from joints, depressions, and water tight by reason of its construction.

At the same time, in case you should require another duct, the wall on one side is always ready, by merely placing a core on top or on either side and proceeding in same manner; this reduces the cost of a new duct. The most convenient arrangement for distribution purposes suggests a line of ducts on each side of street, with man-holes at intersecting streets, and openings at every house lot subdivision.

I have adopted an opening in the form of a cast-iron nozzle, with a hole into which a pipe can be screwed, by removing a screw plug; the same being set in the cement when constructing the duct, leaving the nozzle projecting only. This can be modified to suit any size or shape, or the nozzle can be replaced with a box having a lid. This form of construction will permit the conduits to be placed near the surface; the elasticity of concrete enables it to withstand the blows caused by heavy traffic. It is an easy matter to project a conduit of this form from a man-hole to any desired point, and afterwards to construct others alongside at small cost.

The cost of constructing ducts by this method is narrowed down to the winding of the ribbon on the mandrel, the labor of removing the mandrels in the trench, and removing the ribbon from duct, and re-winding the ribbon on bobbins.

As each part of the core is preserved and used an indefinite number of times the cost of the core is charged to cost of plant; it costs ten cents per foot. The winding of the ribbon is done on the spot as fast as wanted, and costs two mills per foot, the cost of drawing out the ribbon and re-winding on bobbins, using an ingenious device that removes all twists, costing about one mill per foot. The labor for removing the wooden mandrel in the trench is about one cent per foot. A duct 4″ in diameter, made of con-

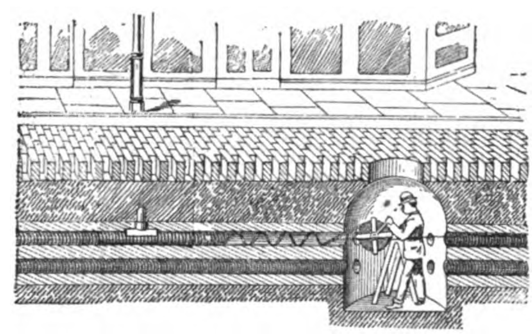


FIG. 5.—Chenoweth Conduit.

crete, one of cement, two of sand, can be made for four cents per foot, including entire cost, exclusive of excavation, man-holes and openings. In case a repair should be found necessary a block can be made with a duct through it, and inserted between the two ends thus to be joined, leaving a space of one inch at each end. Insert a spiral sleeve inside of duct, made of iron, a wire fastened to the end of ribbon forming the sleeve (also connected to sleeve at other end of block by wire), then extend to nearest opening, pack the cement between the ends firmly, the sleeve preventing the cement from entering conduit. When the cement forming the joint becomes hard, the sleeves can be removed by hauling on the wire at opening.

The president then announced that the afternoon session would be devoted to the discussion of the general topic presented in the three papers just read.

The chair then announced the appointment of the following committee on the president's address: Messrs. Arthur Steuart, of Baltimore; A. F. Mason, of Boston; J. Frank Morrison, of Baltimore: E. R. Weeks, of Kansas City, and H. D. Stanley, of Bridgeport, Conn.

The President—I understand that the Brush Electric Light Co. have commenced putting in their cables at the corner of 15th street and Broadway. Before we adjourn I would like to ask Dr. Wheeler if he knows whether they will be at work for the next two hours, and if so we will arrange to allow those of us who wish to see them at work an opportunity to go there.

Dr. Wheeler—The men will be at work there by the time the members of this association can get there. I think they go to dinner about half-past twelve.

Mr. Lynch—Before we adjourn I would offer the following resolution:—

"*Resolved*, That a committee of five be appointed by the chair to examine into and report upon the systems of underground conduits for underground conductors and conduits now in operation,

and the number of wires actually in use in those conduits, and report at the next convention of this association."

On motion the resolution was adopted.

The convention adjourned till half-past two o'clock P. M.

THURSDAY AFTERNOON SESSION, AUGUST 30.

The president called the meeting to order at 2.30 P. M.

The President—In the absence of the secretary I will read the following communication which has been handed in :—

"If desired by the members, arrangements will be made for those attending the Broadway Theatre to see the electric light plant there. As this plant is a very complete one, and was installed under the inspection of the navy officers, it has many interesting points." C. J. FIELD."

The president also read an invitation from the Shultz Belting Co. to examine, at an establishment in this city, a belt said to be the largest in this country.

The President—We are now ready for the discussion of the three papers which were read this morning. I see that Dr. Wheeler is present. Some of the gentlemen, after the reading of his paper, were asking some questions, which the chair stopped, as they were leading to a general discussion, but Dr. Wheeler will be ready now to answer any questions which may be asked him.

DISCUSSION ON SUBWAYS AND UNDERGROUND WIRES.

Mr. Lynch—I would like to ask Dr. Wheeler what number of wires it is proposed to put into these two and a half inch ducts.

Dr. Wheeler—I do not know exactly how many they propose to put in. I suppose it will depend on how many the ducts will hold. But there is now being drawn into them a cable containing eight arc light conductors, each one of which is equal to a number four wire. They are made a trifle larger than the ordinary overhead conductors. That makes a cable which, including the lead covering, is about two inches in diameter. I should think it hardly advisable to draw a larger cable than that through these tubes; but hereafter probably there will be no cables drawn in containing more than one arc light conductor. They will be drawn in singly. The objection to the cable containing a number of conductors is, that it limits the use of the cable to carrying a number of wires all forming the positive or negative side of the circuit, while if you make them up into single conductor cables you can arrange them to suit the convenience of business, and you have an increased amount of insulation between opposite wires.

Mr. Lynch—How far is this cable to run?

Dr. Wheeler—From 14th street to 34th street on Broadway.

Mr. Lynch—What is it to be used for—trunk lines?

Dr. Wheeler—I do not know exactly; I think not, from the fact that it is proposed to cut it in two at each man-hole.

Mr. Lynch—Have any supplementary conduits been laid?

Dr. Wheeler—None have been laid that I know of for the use of arc light companies. The method has been adopted and the materials are being gotten ready to lay a system from 14th street to 34th street on Broadway.

Mr. Lynch—Is that the Johnstone system you spoke about?

Dr. Wheeler—Yes, sir.

Mr. Lynch—What is it proposed to charge as rental per mile?

Dr. Wheeler—I do not know. For that I will have to refer to the representatives of the conduit company.

The President—Dr. Wheeler, will you allow me to ask you a question. If the city authorities have charge of the streets and are responsible for that conduit going in there, how then are you going to hold the owners of the lateral wires responsible for anything at all? How do you propose to do that? Has the commission any plan on that point?

Dr. Wheeler—It occurs to me that that is a question of law, and I am here as an electrician—not that I have any objection to answering the question, but I do not know the answer.

The President—I see. But is the representative of the law department here?

Dr. Wheeler.—I would like to refer that question to Commissioner Gibbens, if he is present. I do not see him.

The President—We are seeking for information, and we are as desirous of a solution of the problem as the municipal authorities are. When we get to a point where there is a dead line drawn and the municipal authorities cannot give us any information, we have got to stop right there. If there is a point where we can give you information, we are desirous of aiding you.

Dr. Wheeler—I am very desirous of having all possible information given to the association in order to make the conclusion reached as valuable as possible, but in the absence of Mr. Gibbens, perhaps Mr. Leslie, who is present, and is the manager of the subway company, might answer that question.

The President—You understand the proposition,—that as the municipal authorities by law take charge of the mains and regulate the sizes of the conductors, etc., and become responsible for those mains in the street, then, as I understood the proposition this morning, the companies who would feed off from those conduits would be responsible for the lateral mains. Is that correct? Now then what we want to know, if we can get the information, is this—where the responsibility of one commences and where the responsibility of the other ends.

Mr. Leslie—As I stated this morning, I think the responsibility of the subway company ends in providing a suitable subway for the accommodation of such conductors as any electric light company or any other company may see fit to draw therein. They are responsible for the kind of insulation and for the operation of their own plant; they own it; we do not. We simply own subways which we lease to them.

The President—Then, in other words, as I understand it, the city authorities have practically made a monopoly of the underground business of the streets, and given it to a certain company without any specifications as to the character of the conditions that the lighting companies must undertake to fulfill in making connections with the main conduit system. Is that it?

Mr. Leslie—In the first place, as I understand it, when the commission was created, each and every party interested was invited to submit its plans for such a system as in their judgment might be most suitable to their business purposes. Having failed to do so, the subway company has since observed the same practice, and each and every company in the City of New York doing business here has been invited to state what in their judgment would be most suitable for their purposes. I think the attitude of the subway company in that respect has been most consistent. If a man wants anything and asks for it and gets it, I do not see that he can ask for any more.

The President—Then, as a matter of fact, the subway commission of the city does not say to the electric lighting companies that they must observe proper sizes of wire, and everything of that kind. They leave that to the discretion of the company.

Mr. Leslie—Entirely so.

The President—They simply ask them to make a recommendation?

Mr. Leslie—They ask them to go underground.

The President—And if it does not suit the conduit company, what then?

Mr. Leslie.—We have had no such emergency arise as yet.

The President—Is there a basis then established by the subway commission or the company under the subway commission—is there a set of fixed charges established?

Mr. Leslie—There is, and it has been furnished to the companies.

The President—Have you received answers from the companies in regard to that question?

Mr. Leslie—We have met with no opposition in that respect from any company in the city except one.

The President—They are all perfectly satisfied with the rate of charges?

Mr. Leslie—They appear to be so. They think it to be just and equitable.

The President—In the furnishing of this subway, do you give any guarantees to these companies as to the permanency and the reliability of the system that you put in?

Mr. Leslie—We agree to keep the subways in good order.

The President—Practically, you agree to maintain them free from trouble.

Mr. Leslie—Yes, sir. But if anything that could not be anticipated should arise to interfere with their business, they would not be in position to be reimbursed for any loss they might have incurred during that time.

The President—Then practically, you do give them a guarantee?

Mr. Leslie—We guarantee to give proper subway facilities or we do not charge any rent; that is the best we can do. If we should happen to have some extraordinary accident which no one could anticipate or provide against, in that case we should, of course, abate any rental until such time as we could put the subways in good condition.

The President—Then there are no conditions by which a company which is held responsible for lighting to the public could obtain redress for lights being out for a period which would be practically inconvenient and would cause considerable delay in restoring service?

Mr. Leslie—I do not know of any guarantee beyond that which I have stated.

The President—Yes, that is what I understand. Then it is the companies which practically loose the amount of revenue that would be lost, instead of the subway company that puts in these conduits?

Mr. Leslie—Well, I presume so. They do so now with the overhead system.

Mr. Perry—This is a subject that is entirely new to us and we may have to meet it in our own various systems, and I would like to ask what are the rates of tariff which are established here, and if the City of New York gives into the hands of a corporation the right to lay these subways without any limitations as to what tariff they should charge, and then say to the companies, you must go in, no matter what the rates are? I would ask if there is any limitation of the tariff and what the rates of the tariff as established are?

Mr. Leslie—I will say with regard to that matter that the companies are amply protected. The law on that subject reads

that such a rental shall be charged as is fair and equitable. Any company imagining itself imposed upon in the matter of rental, can have recourse to the board of electrical control, which has the right of revision at all times. I regret that I have not with me a copy of the law on the subject, which I imagine from the inquiries which have been made would have gone very far to enlighten the gentlemen present. There is no opportunity for unjust action.

Our schedule of rentals is $1,000 per mile per annum for a three inch duct; $800 per mile per annum for a two and a half inch duct; $750 per mile per annum for a two inch duct; $550 per mile per annum for an inch and a half duct. I will say that with regard to the two inch duct I am not clear whether it is $750 or $650, not having the figures with me.

The President—You will understand Mr. Leslie, that these questions that we ask are not asked in an inquisitive way to ascertain the private business of the subway company; but this City of New York has been looked to from all over the United States as the point where this question is to be solved. We have been invited by the mayor to go into the merits of this matter if we can, but there is no use in going into the electric part of it unless we can get at the financial part of it too.

Mr. Leslie—I appreciate that, Mr. President, and I want to say that while the scope of our operations is local yet we recognize the fact that the underground problem is universal, after all, in its application, and that in most of the prominent cities of the United States you are all face to face with the same question, and that the developments of underground facilities in other cities is going to be directly and indirectly a great help to us here in New York. I desire to say further, that if any individual member of the convention desires any more definite information upon the underground system, which we may possess, if he will apply at our office, 18 Cortlandt street, in this city, we will very gladly give him all the information that we have.

Mr. DeCamp—As I understand the matter, when this subject was put into the hands of the subway commission, they invited the different electrical interests to state to them what was necessary for a successful solution of the problem of laying underground wires. These different electrical interests, particularly the electric light interests made no response to that invitation, for the reason, which is manifest to every man engaged in the electric light business, that they had no suggestions to make because they knew no practicable method. Then the subway commission took upon themselves the responsibility of deciding upon some conduit which in their judgment would answer the purpose. Those conduits have been put down not upon any merit that has been demonstrated; but as mere mechanical constructions they seemed the proper thing. After that is done then comes the pressure to have the electric light companies put their wires in them. That pressure is brought to bear very forcibly because it is backed up by legislation. The commission have assumed the responsibility of deciding for the electrical companies in putting down a certain conduit; but they throw off their responsibility and say, "Gentlemen, occupy those conduits at a rental of so much a mile." The only risk that they take in the matter is in keeping the conduits in repair. They throw the burden on the electric light companies, and as the chairman very pertinently puts it, who is responsible to the electric light companies for the loss of service to the public by reason of the failure of the conduits during the time it is necessary to repair them? Not only that but the failure on the part of a cable or conductor that they put in, though not upon their own judgment but upon the judgment of the parties who put the conduit down. There is a consequential consideration or risk there which, in my judgment, it is unfair to impose upon anybody. That is about the way, as I understand, that the thing stands to-day. There is only one certain element in that for the companies using the conduits and that is—to pay rent. But leaving that right there, this is what has always occurred to me from the time this question was agitated. It has been taken hold of at the wrong end. I never saw a more preposterous method of accomplishing a thing. Mr. Lynch asked a question this morning about a certain conduit in Philadelphia. That that conduit in my judgment is a good one goes for naught. I do not care how good it is, and I do not care how cheaply it should be built, but I have got absolutely nothing to put in it that will answer the purposes of our business—absolutely nothing; and here you go to work and you devise a convenient method of transacting a business which you admittedly do not know how to carry on. There is not a man to-day who is willing to take the record of the aerial lines as a basis for operating, and that is of no mean importance, because the investment of a vast amount of capital and its earnings are based upon the amount of money in those constructions, and you never get any more out of it. You have reached the maximum reward of the investment of your capital. The public has given it to you and given it to you willingly. They say to you: Your business now, young as it is, is old enough for you to have learned something, and you have brought that business to a point at which it ceased to be a luxury to those who want to use it. The City of New York paid 70 cents per night for arc lights without a murmur in the first few years of the business. They declined this year to pay 50 cents. They declined to pay 45 cents, and there are plenty of cities in the country that are paying less than that. They say it is too expensive. Therefore, you have got to weigh with great deliberation anything in connection with your business which compels you to increase your prices or to maintain those you have already established. The commission put down these ducts; they have occupied the streets, and they have left the companies who shall choose to use them to accomplish that great end of getting something to put in them. Now I asked the question this morning of Dr. Wheeler, who represents the subway commission, what these conduits cost. He does not know. The matter is referred to Mr. Leslie, he does not know; and from all I can learn nobody has ever taken the trouble to consider the cost of this thing. Now I want to submit that as a method of doing business. When I go to my company and say "There is a report; it involves the introduction of new machinery, the addition of a few boilers, the addition of some electrical apparatus that will enable us to do so much business; it will increase our business 10, 15, 20 per cent." do they say "Go on and do it?" It is just what they want done; but before they do that they ask, "What is that going to cost?" The commission have gone before the authorities of the city who are pressed on all sides to do a very desirable thing. Their plans look very feasible as a piece of engineering. His Honor, the mayor of this city, takes the most sensible view that ever I knew a public officer to take. (Applause.) He is a man who has the courage of his convictions, and it is a great disadvantage to the electric interests to-day that there are not more of our municipal officers who seem to have the same courage. The mayor of this city stands in a position which no electric light company dare antagonize. If this subway commission brings forward a practicable system and he carries out his intentions of enforcing it, I do not believe there is an electric light interest in the City of New York that dare for a moment antagonize him. Certainly there is not in Philadelphia an electric light interest that would dare to antagonize a municipal officer taking such a position. Now that is a sensible view to take of it. It is a question of dollars and cents, as has been many times asserted on this floor. That assertion amounts to naught until the amount of those dollars and cents is stated. This thing carried on to the extent it is proposed to be carried on in New York, if I have an appreciation of the subject at all, would ruin every electric light company in the United States, and every dollar of capital invested in it would be wiped out. No industry that ever started has sustained itself as this interest has sustained itself since its inception. Gas companies never met with the same obstruction nor did any other public industry. Just as soon as the electric light companies impressed themselves upon the minds of the public that they were a public necessity, every facility was offered and no obstacle was set up any longer. We are met here with this subway project, commencing as I say, at the wrong end to do an important thing before we know how to accomplish it. As to the guarantees. I can readily see how the commission cannot assume that responsibility. It is utterly impossible for them to do it. It has been said here that certain manufacturers will put a cable in with a guarantee. Now I understand that that has been done in this city. I am curious to see in what form that guarantee is. If it simply means "we will put that cable in there and run it for a year or two, or three years, and in case it fails we will take it out and put in a new one;" in my judgment it does not mean anything. Who would think of renewing the gas pipes in the City of Philadelphia? What electric companies at the present comparatively low cost of aerial lines would think of renewing their aerial lines once in ten years absolutely? It would make the business prohibitory. The substitution of a new cable is no small job; the consequence is that while it is being substituted the city is without light. Now that is a thing that the companies themselves should be compensated for. It is not likely they would be. In the City of Philadelphia and I think in the City of New York there was not a gas light removed on the line of electric lights for one year after they were started. Why? Because confidence was not established in it. People thought it might go out on them. But gradually confidence got established, and now wherever it is possible gas light is turned out, and the very rare failure on the part of the electric light has justified that confidence. I am sometimes amused at the easy, self satisfied way in which people say, "What does it do? Pull this right out, and put another one right straight in." On the same cable, perhaps within two available points for making the change, are half a dozen different connections all of which have got to be unsoldered and the cable taken out, another put in and the cable soldered up again; that means a delay and the loss of a certain order, public or private, and I assure you—and any man that is in the business needs no assurance—that such a thing as that would not be tolerated. Customers would say "The thing is too uncertain; we do not want it. If these things are to occur even occasionally it fails to answer our purpose." When it comes to that, gentlemen, your electric light as a common and public illuminant is a failure.

Now I am just as anxious as any man to have this question of underground wires solved, and I believe every company in the

country is willing to do their share of it and are making the best efforts to do it; but you can readily conceive when you look at the City of New York and note the progress that is being made in it,—I mean the substantial progress—that it is not very encouraging to us to go to our companies and ask them to spend money to repeat the same operations that have been made in New York. That is not business. We should benefit and profit by other people's experience. It is one means of education that we have without paying for. In the City of Philadelphia we have made our effort. It is not expected that the people of Baltimore in the same line of business will go and do just the same thing that we are doing, but every effort has been made in Philadelphia from a straight square out and out business standpoint based on an investment of capital, to meet the public demand. I declare here without fear of contradiction it has been an absolute failure. The parties that have been endeavoring to make a success of that have had every interest in the world to bring success about, and yet it is a failure and there is no denying it.

Professor Van der Weyde—Our mayor, notwithstanding he said that he did not understand much of the electrical business, gave us very good advice to devote our efforts to solving that great problem. I have been attempting to solve it for some years. When I first saw that the wires would have to go I made individual experiments and have patented cable. I have also obtained patents for anti-induction cables, but in the place of getting up a company to try to introduce it I put it to a severe test myself and I found, after burying the cable that it did not stand the honest test; and therefore I have not come before the public or before any company with my patent. The position of the matter is this: There are two things to be accomplished by us. In the first place we have to devise a subway which is available in a large city so that the cables can be gathered. It is a significant fact that in the City of Paris, where they have the most magnificent opportunities for putting the cables underground, in their sewers, only the telegraph and telephone cables go through the sewers, and all the electric light cables, as stated this morning, go over the roofs of the houses. It has been found not to be practicable in Paris. It is a problem to be solved. We must find first the proper cable to put underground, and then the proper subway. We have seen this morning a cable passed through the tubes. That is very good and very useful, when we have to go a considerable distance, like passing over the Brooklyn bridge or the approach to the bridge, for instance, through Frankfort street; it is splendid in such a case; or uptown through Broadway. But if we want a system where every wire is accessible, it is insufficient. Such a system has yet to be devised. In the second place, proper cables have to be devised which will not give out, and the best we can do is—what I have done, Mr. President—to recommend this body to make their individual effort to improve the things we have and to get subways which will answer the purpose, and to get the proper cables. By the way, in Brooklyn, for instance, the subways have been laid down under my sight as it were. I saw it from time to time, living there. Three years ago they commenced, and what has been the result? They are now pulling out the cables they put in three years ago. Their cables have been found insufficient. If things had been commenced after we had the proper information, then such losses would not have happened.

Dr. Moses—Mr. President, I have just received a despatch which exemplifies better, I think, than almost anything else, one of the bursts of eloquence of the mayor which he gave us yesterday. He said he would like to see electricity really the servant of man for the good of all. This despatch exemplifies how electricity may come to our aid and bring those who are in sympathy with us, though three thousand miles away, right within sound of our voices, and close enough to touch the chords of our hearts.

Dr. Moses, Hotel Brunswick, New York:

"Reckenzaun and friends send greeting to the convention." (Applause.)

Gentlemen, while I am upon the floor I would like to correct an impression which, coming from one of so sound judgment and so painstaking as Professor Van der Weyde, may have impressed you deeply. He says that the subways in Paris have not been used for reasons which would lead you to infer that it is due to the fact of the incompleteness of our knowledge in the distributing of electricity through conduits. That is not exactly the case. The facts of the case are these: The City of Paris and the gas company are in a close partnership. They do not want to have any electric lights there because one of their chief sources of revenue is gas. We often hear a great deal said about Paris being the representative city for everything that is in advance in science, art and luxury, and we are inclined to say this thing should be developed there. To-day there are not half a dozen arc lights in Paris outside the Place du Carroussel. The reason is, the city found every impediment in the world in the way of electric lighting. It is bound to come though, and those who are deeply interested in the subject in Paris are bringing it about in the following way: A company has been started in Paris which is seeking rights from the municipality to introduce a system of power throughout the City of Paris. They entirely ignore the uses of it—electric light, transmission of power for motive purposes, for electrolysis, for all the other uses to which we apply it here, are entirely ignored by them, and they propose simply to sell power. Now when the time comes, of course for the distribution, it is not impossible that the magnificent system of sewers which underlies tariffs may be utilized by any company that may have the right to do it. That right will only be conferred on those who can give guarantees. Those who are introducing the electric current for power purposes in Paris, are a syndicate, or rather a company controlled by the house of Rothschild, so that there is every guarantee in the world that when that thing is undertaken it will be done thoroughly and no doubt successfully.

I am now tempted to refer to something that has been upon my mind for quite a time, and at the end of this discussion I feel inclined to bring it before you—not in the prophetic spirit to which you have been inclined to attribute most of my address, but because it seems to be the solution of the distribution of power in the City of New York, in which, as Dr. Wheeler has said, more business is done in a small place than in any other spot on the face of the earth. The subway commission have undertaken a great task, and as far as they have gone they have done it as well as the present state of the art will permit. That is a meed of praise I think we will all accord them. But I am tempted to think of an anecdote which Mr. Barnum relates in connection with that. I do not intend by quoting it to cast a reflection on the subway commission. Mr. Barnum says that in his experience one of his friends got married and received a present of a very magnificent velvet sofa, very comfortable to lie on but not at all in keeping with the length of the young man's purse. He did not have it long before it was found necessary to change all the furniture in the parlor. That necessitated a change of all the furniture in the dining room, and that was followed by a change of all the furniture in the bed room and the whole house, and if it had not been for an unexpected run of luck that young man would have been ruined by his sofa. Now several people have acted in such a way as to furnish a magnificent conduit. It will be furnished, and the fruits of it will be enjoyed as this young man did through his unparalleled prosperity, and electrical power will be distributed through the ducts now in the city under the control of the subway commission, and it will be a success. But I will suggest that it may be done most advantageously in this way: If we look at the supply of light, water and steam that we have in New York, we find that everything is distributed from a central point at an equal pressure. If we were to use the 42d street reservoir to-day people would say it is ridiculous, because we have a higher source of pressure. The reservoirs in the park are ornamental lakes sometimes, but even they might be done away with. We might go to High Bridge and put up stand pipes as they have done there and get a uniform pressure. The only thing necessary for the distribution of power to make it available to every consumer is a constant source of pressure and an unlimited amount of power. How are we going to accomplish that? If we look at these subway ducts we will find they are not as in the human body—every artery, every vein, every nerve connected with some simple point of uniform distribution and pressure; but we find through one orifice is to go a power say of 100 volts, through another one of a thousand volts; through another one of 2,000; through another one of 10,000, all acting by varying inductions upon each other, interfering with each other, and really giving you no means by which if an error or a waste is introduced it can be interrupted without in some way affecting the other potentials. That introduces an element of variation which is to be avoided. How then can that be done? In the present state of the art it is as easy as furnishing a mild current of water for washing the hand, or a powerful one to the bath tub, or one still more powerful for taking the shingles or slates off a roof by means of the steam fire engines, all from the same source of power. But we must be able to distribute from a constant source of electrical power potentials of any height. How is that to be done? It may be done in such a way that the original source can be entirely safe-guarded. My friend here speaks of the conduit being a success, but he has not anything to put into it. Why? Because insulation has not been carried to that point of protection where you can say that you have a source of insulation of unlimited light. It is wearing out all the time. Now then we must have a conductor of such character that we can say when it is put down it is never going to be touched; it is a constant source of power, as regular as the sun for its heat, and there it is to be disturbed and changed into any condition that we desire. How is that to be done? Gentlemen, it is done partially for electric lights to-day. You will find conductors, particularly in Pittsburgh—where I saw them very extensively distributed—conductors of very small dimensions going through the streets carrying 1,000 or 2,000 volts and then being distributed in potentials of 50 volts. I would like the ducts of the subway commission built with a series of conductors all electrically connected and having a potential great enough to enable all the force that is necessary to be distributed through this vast metropolis and be permanently there as a source of supply without in any way seriously incommoding our streets. All the current necessary to run all the machinery of the electric light, telegraph, telephone, burglar alarms, and so on, could be carried

through a conductor one foot in diameter that could be laid through the streets of New York. It could be so carefully insulated that not 100 millionth of it would be wasted. It could be made available at any spot in the smallest quantity and in the largest. Let any accident happen to any piece of machinery, and it should not be able to interfere with the enormous power behind it. There must be nothing to interfere with the great current of force that should circulate through the city. That to my mind is the *beau ideal* of the distribution of power. Now, then, how to do it. We are stumbling upon a thousand difficulties, but I think they can be arranged. You have interests of various kinds—electric lights, power, and so on,—all of them running antagonistically: How can they be persuaded that such a system as this is best? Simply by showing to them that they may unite their forces for the furnishing of this power. You cannot put up in any one place a station that would be sufficient to supply the whole of it. It should be like a series of ganglia pumping into this great main artery the power that is necessary. Let them all pool their issues and pump into one station and from that point let it be distributed, if you please, by the underground commission or by any one who will take charge of it. Let the source of power distribution be the essential feature. It is immaterial to me whether the power is used for lighting or another purpose; power is at the bottom of it, and power should be furnished in the most equitable and most useful way.

Now that is not by any means Utopian. It would enable you in the smallest area to safeguard your current in such a way that it would not be interfered with by any other interest. It should be distributed through all the streets of the city just as water is. It can be done, and in a very much easier way than people imagine. Gentlemen, to my mind that seems to be a solution of this whole difficulty. Of course for minor distributions that can be very easily accommodated, because between any two blocks you have but a small sub-distribution to make. That can be easily accomplished. Transformers of current can be put everywhere and anywhere and attached to that main source of supply and measured in the simplest way possible without any danger. We would have arc lights in our houses then. Do not think, gentlemen, that I am trying to derogate from the importance of the arc light interests. People instead of having arc lights in the streets would be satisfied to bring them into their rooms if they knew there was no danger. Transform your current from one of 2,000 volts into 50 volt currents, and you will find your interest will be ten-fold magnified inside of a year. Gentlemen, I have nothing further to say, but give you that to digest.

Mr DeCamp—The remark of Dr. Moses lead me to think that I might have been misunderstood. I believe with him that almost anything is possible. I do not by any means wish to convey the impression that we will not reach this very desirable end. While I do not propose to be a skeptic in this matter, yet on the other hand I do not propose to be an enthusiast. I cannot discuss that question from the point of view at which Dr. Moses and many other gentlemen in this association are entirely competent to discuss it. That is not my line of business. I am simply a man in the business who has to look out for the financial interest of his principals. I have got to see that their investment is properly made and reasonably remunerative. The chairman asked me to make some figures, and I submit them, knowing that figures not supported by data are dangerous things to deal in; but I want to submit them and take the risk, depending upon the good judgment of the members of this association who have experience in that line to believe that I am conservative in regard to these figures.

Eight hundred dollars a mile rental for the use of conduits—not the furnishing of wires and circuits, but simply as a tenant, $800 a mile for a conduit or duct which cost $500 a mile. Now the gentlemen who framed that schedule must have had in their mind's eye a wonderful depreciation to ask more than 100 per cent. on their investment the first year; but admitting that it may be justified by something of which they are the most competent to judge, my experience in the conduct of an electric light station is that it is a pretty difficult thing to distribute more than 50 lights in a circuit of two miles. We do not do it in Philadelphia. But I am going to say two miles for 50 lights, a 1,000 light station under those conditions—I wish somebody would go over this after me.

Mr. T. Carpenter Smith—I would like to ask if that $800 rental refers to the ducts or to a single wire?

Mr. Perry—It was stated that it was a single duct—a $1,000 a mile for a single three inch duct.

Mr. Smith—Suppose Mr. De Camp keeps to the conditions that apply to the cable now put in.

Mr. De Camp—That is a thing in which you might do yourself injustice. I will come to that point before I get through. Now to answer the question on the basis suggested, it is true that it does not follow that our mileage should be the number of lamps divided by 25, because certainly as a matter of economy in rental we would use the same duct where we could until we got it full. Now to what extent you could do that is a matter that is only guess work. But I cut it in two—divide it by two if you choose and pay $80,000 rental a year for a 1,000 light station and figure out where your dividends would come from. Divide it by four—

Mr. Apgar—May I offer a suggestion here? Could Mr. De Camp reach the conclusion he seeks—I see what he is after—by ascertaining what it would cost the whole plant with which he is connected to put that whole plant in the ducts furnished from $550 per mile per year to $1,000 per mile per year. He knows how many miles he has in circuit and he can determine what would be the annual expense for rental by placing all of these wires in ducts. You could reach that quite readily could you not?

Mr. DeCamp—No, I could not do that quite readily. Anybody who has had experience in distributing light for a central station knows that his first calculation of the first cost is apt to be deceptive. Now we run wires from our central station, not with the view to supply the particular lights we may run them for at first, but we run over a district, if we have the privilege and opportunity of doing it, by which we think we can utilize that wire to the best advantage. In other words, we might go to get 10 lights, in a direct line of a mile, if the 10 lights were our only object. Very probably we would choose to put out five miles of wire, over a territory from which we would draw other business. Therefore, for me to make a statement on the basis of the wires we have got would be more uncertain than the figures I have already stated.

Mr. Smith—Mr. DeCamp has made one statement which I think is entirely right—that this question of underground wires has been taken at the wrong end, but I do not agree with him as to the way in which it has been begun at the wrong end. I maintain it has been taken at the wrong end in some cases, because the men who have been getting up these various reports on underground wires are the men most directly interested in underground wires not being a success. We are told over and over again of the failure of underground systems, and it reminds me of the old story of the man who had stolen the cow, and one person was produced who saw him do it, and he replied that he could bring forward 20 men who had not seen him do it. Now I maintain that in a case of this kind one good instance of successful work is worth 40 instances of bad work. When Mr. De Camp states that there is no successful underground work in Philadelphia I think he must have forgotten what I told him in Pittsburgh, that I had 15 miles of wire running underground in Philadelphia without any trouble. We supply eight newspaper offices, and I think any one who has ever supplied a newspaper office will agree with me that they are the hardest to please of all our customers. Those eight newspaper offices have cut off their gas entirely and are entirely depending on our supply. We are using 1,000 volts of alternating current. We have never taken out a single cable but one. That was a small piece of double conductor No. 10 wire which we pulled out owing to a short circuit having taken place in the cable itself, and we had the lights running again in six hours.

A great part of Mr. DeCamp's speech was taken up with what seemed to me to be simply an attack on the subway commission in this city. Now with all due deference to the subway commission here, I do not see that their action in this city has very much to do with the convention. It is very hard on electric light companies, I grant you, to have to pay any such rental as $500 per mile per year, but Mr. DeCamp has been very anxious to know what it is going to cost to put the circuits underground. I have laid altogether somewhere between five and six miles of underground work in a 16-duct box, fitted up complete, with three man-holes to every square, counting everything from the digging of the trenches to the repaving and giving a bond to the city, will cost him about $7,000 a mile. That does not include the cables to be drawn in. He has made the statement that matters of this kind are put in the hands of men to legislate upon who know nothing upon the subject. Very true. Now I happen to know of a commission that is appointed to examine into the question of underground wires, who came to a certain city where there were a number of arc lights which were reported to be running satisfactorily by the man who was operating them, where there was an incandescent station operating from 2,200 to 2,500 lights on underground wires, running for two years without any trouble, and a gentleman who had a large arc light station in that town got hold of that commission, took them around in carriages to the park and to the theatres, and that commission went away without seeing a foot of underground wire, and I have no doubt made a report on it. That is a good way to help people who are ignorant of the subject to find out about it. But it is hardly the way a business man would go to work. I am afraid I may be looked upon as a crank on the subject of underground wire. I have put money into a company which has to use underground wires for the reason that other people have got all the overhead privileges in the town and will not let us get any; consequently we have to go underground. (Laughter.) There is some advantage in starting out in knowing just what you have got to do. You know you have got to spend your money and you are going to take the best care and to get the best work; but the man who has already spent his money, of course naturally objects to taking that all out and starting on the same ground as we have. With regard to the whole question I wish to say a few words upon

it—the results of some patient investigations on my part. I would say that the whole question of underground wires has not been attacked in the right way. The first question is how are you going to distribute the current, and the second is, what effect are your methods going to have on the public. Now it seems to me any system that involves the laying down of enough conductors to supply the business you have in prospect in the next 20 years is a mistake. There is a company in Philadelphia now which has stated that they have spent $250,000 on the copper in the mains in that city, covering a district two miles long and a quarter of a mile wide. They say they expect to put 50,000 lights on those conductors and I guess they may get them in about 20 years. Now if instead of that copper, which by advance in our knowledge may be rendered entirely useless in the next five years, they had put money into conduits it would not have cost them anything like that amount. Now if we start with the idea that you must not have your conductors buried—the actual metal required buried at once—it seems to me that the only thing you can use is a conduit that will allow you to increase by drawing in cables. We know what a conduit will cost. The greatest expense in a conduit is the trench and the repairing of the street afterwards. That would amount to anywhere from 35 to 40 per cent. of the total cost. If you put down a conduit into which you can draw additional cables afterwards you are saving as much as possible of the original expense; not only that, but you are getting rid of the greatest opposition to the underground system—the objection of the citizens to having the streets torn up every time you have a break or want to make a connection. At present all the people in the electric field have the misfortune to be damned by the newspapers for not going underground and doubly damned by the people for tearing up the streets to do it. We reach the point that you must have a drawing-in conduit, and the next thing you must have is the means of distributing the current to every house in the block without digging up the street. That can only be done, it seems to me, by having a small distributing duct running alongside your trunk lines to which you can make your connections the same as you would with a water pipe or gas pipe. The people will make no objection to that. There are such systems; there are dozens of them, and it is not so much a question as to which system you will adopt as that the work should be carefully and honestly done on the start.

The arc light question is one which practically I know little about, but we have heard this morning from Mr. Acheson that the great trouble from the puncturing of the cables evidently arises from the static charge. Now in an arc light circuit, it seems to me that static charge would only arise at the moment of opening and closing the circuit or at the flashing of the machine. In an alternating current, with which I understand Mr. Acheson made his test, the charge is there continuously as it were. Now I have noticed on an arc light circuit a peculiar condition that took place where I was using a couple of ordinary Thomson-Houston lightning arresters on the ends, where every time we opened and closed the circuit we would get a spark across the lightning arrester; and on a night when the machines were working badly I have seen a continuous static spark running across, but I never thought that was a solution of the matter until I heard Dr. Wheeler's paper.

Now I have noticed also a rather curious thing that occurred on our circuits with the alternating current machine. We had three armatures give out without any sign whatever. They tore all to pieces. We examined them as carefully as we could and came to the conclusion that there had been a short circuit in the wire of the armature itself. The men told me that regularly for two or three days before the armatures gave way they saw the sparks on them. Owing to one of those break downs we had to overload a machine one night, and one of the men told me that the machine was sparking. I found a little spark jumping from one of the pole-pieces into the armature, a very bright little spark. I came to the conclusion that it was the charge in the belt. The machine was insulated on a good dry floor. I ran over to the ground detector and I found a slight leak on one of the circuits. I concluded that that was a static charge from the belt. I threw a little of the load off the machine and the spark stopped jumping. I put combs on the belts and we have had no more sparking of that kind. I examined that armature and I found that the mica covering the wires was punched, and that is satisfactory evidence to my mind that the spark went through there continually. Now I have had the same thing occur on the line where there is a constant sparking from opening and closing the main circuit, where the spark would jump through anywhere from five to six inches and finally burn right through the insulation, then we would get grounds and we would find a little hole burned through. Now when the convention met in Pittsburgh last spring, I told them I had a good deal of cable out there on the Monongahela bridge running electric lights. I had in there two .0000 cables, 85 to 90 amperes. Those cables ran with perfect satisfaction save one burn-out occasioned by lightning. It fused the copper wires of the conductor together. A piece of three or four inches was cut out and the cables have run all right since. But a little cable we put in there had a very curious experience. The question was raised whether pulling a lead covered cable into a creosoted box would not cause the lead to decomposed and the proposition was made to cover it with some sticky tar compound. I thought I would improve on that by covering the cable with a braiding and saturating that. I put the cable in and told the men to ground it thoroughly. The first night we ran we punched 17 holes in it. I spliced it up and went ahead and the next night it broke out in three places, and I found that the men came to the conclusion that it was so nicely insulated it did not need to be grounded. We grounded it and that was the end of the trouble. The cable had been ruined however and we took it right out. Now that cable when I examined it in a great many places showed no sign whatever of injury to the cable, but the lead was melted right out and had run away. I supposed that was due to the static charge escaping at that point.

If there are any gentlemen who have any questions to ask about what success we have had I should be glad to answer them. For the arc light side of the question I would call on Mr. Sunny. I should like very much to hear from him now as to what his experience during the last six months has been with the additional light he gained at the last convention.

The President—The chair is compelled to call the discussion back to the main point. A good deal of irrelevant matter has been thrown into this discussion during the last hour. The point about it is this: The subway commission came through a representative before this convention with certain statements. Practically they amount to this—that they are putting down a conduit system, that they haven't a single arc light wire working through that system, but that they hope by the 1st of October or sooner to have several. They elaborated the plan and go on with it, but do not tell us what the conduits cost.

Dr. Wheeler—Pardon me. I do not think that statement is so, that no cost is given. As I understand it the cost is given to people who come and inquire for it in the proper way.

The President—The gentleman will pardon me when I say that the question was asked here on the floor what it cost per mile of conduit and there was not a man on the floor of this convention who could answer it. In the paper itself there is no cost given per mile. It is eliminated at the present time from the discussion. The commission says "examine the way these wires are put in and form your own judgment, and we should like it if you gentlemen would make any suggestion that would help us." Now if there is any gentleman who has any suggestions of that kind let us hear them, let us discuss them. If there is any question to be asked these gentlemen who are laying the conduits, let us get that before us and let us go into the meat of the question and take up the general discussion afterwards.

Dr. Wheeler—I would say that I think there is no question about the fact that putting wires underground is a matter of considerable expense. In reply to the inquiry as to what the expense is Mr. DeCamp says I replied I did not know, and that Mr. Leslie replied he did not know. I replied that Mr. Leslie was the proper man to answer that question, and I think Mr. Leslie said that the proper way to obtain an answer to it was individually to make that inquiry at the office of the company. I do not think it is correct to state that Mr. Leslie and I said we did not know what the cost was.

The President—We are going back to the main question. These suggestions that are made on the floor as to the cost did not bring out the answer. That is not before us; therefore we cannot discuss it.

Mr. F. E. Kinsman—I wish to ask what was the size of his conductors through which Mr. Smith was sending 1,000 volts so successfully?

Mr. T. C. Smith—All the way from .0000 to No. 16 Brown and Sharpe gauge, from the single conductor down to double conductors in the same cable; we even have one conductor, three wires in the cable, No. 18 Brown and Sharpe gauge running very nicely.

Mr. Kinsman—What is the length of the longest cable?

Mr. Smith—We have altogether about fifteen miles in circuit, but it is so cut up we cannot give any straight length. The longest direct length is 2,000 feet without a break. That was cable that was made for the alternating 1,000 volt circuit. The longest single length of cable intended for 2,000 volts runs up to about half a mile.

Mr. Lynch—I would like to ask Dr. Wheeler if the commission have adopted as the form of conduits an iron pipe covered by hydraulic cement?

Dr. Wheeler—They are authorizing the building of that kind of conduit. I do not know whether you can say they have adopted it or not.

Mr. Lynch—Is there any other city where the same kind of conduit is being used?

Dr. Wheeler—Yes, they are using them in Chicago. In Chicago they had a conduit made of creosoted wooden tubes, in which they tried some arc light wire. The arc light wire set fire to the conduit, and they tried to put out the fire with chemical engines. That did not succeed, and they squirted water into it from a steam fire engine, and kept that up for about a week. They found they could not put the fire out apparently. They took that conduit out and replaced it, I understand, with iron tubes laid in hydraulic cement.

Mr. Lynch—How long has the iron conduit been used there?

Dr. Wheeler—I do not know exactly when that was put in.

Mr. B. E. Sunny—I can answer that. The Dorsett conduit was put down about seven years ago. This creosoted conduit has been down only about two years. It did not take a week to put out the fire, but we could not get at it for some days. We stopped up both ends and thought we would smother the fire by depriving it of air. When we were able to get at the creosoted wooden box we took it up and put down iron pipe in its place.

Mr. Lynch—What was the length?

Mr. Sunny—About 105 feet.

Mr. Lynch—And how many ducts?

Mr. Sunny—Fourteen ducts of the creosoted wood, and we put down some sixteen of the iron pipes in its place. I would say that the telephone people have a system of conduits there made of iron pipes. in cement, the same as is being put down by the subway commission in New York now.

Mr. Lynch Dr. Wheeler, has this Johnstone patent that you speak of as being recommended by the subway commission for supplementary leads, been in operation in this country?

Dr. Wheeler—It has been in operation in Philadelphia and Chicago.

Mr. Lynch—But as I understand Mr. DeCamp, there are no electric light wires in it at all?

Mr. DeCamp—It is used now for an incandescent station. Their arc lighting business was abandoned about a year and a half ago

Mr. Lynch - Those are the only two places. This system adopted in New York is in use, 105 feet used for electric lighting in Chicago; the same kind of conduits as now used in New York, wrought iron pipe surrounded by hydraulic cement.

Mr. Sunny—Well, I ought to state in addition that, as to the section of 105 feet, at all the street crossings where we want to cross from one side of the street to the other, it is all iron pipe. Then we have added within the past two or three years a considerable length to the original Dorsett conduit and put it in iron pipe.

Mr. Lynch—What do you use in the form of supplementary ducts in Chicago?

Mr. Sunny—I scarcely know what you mean by that.

Mr. Lynch—In New York they have a main line of conduits running straight through the street. Entrance to the conduits is through the man-holes, which are at every corner.

Mr. Sunny—You understand that in Chicago the sidewalks are all hollow, and the main line of conduit is built along the street the same as in New York. From the man-hole we have what we call laterals running into the four corners of the intersection. We carry our cables in there, and then along under the hollow sidewalk, cutting loops for each subscriber as the service may demand it; so that the question of the distribution of power and light is an exceedingly simple one in Chicago, which is probably the only city that is so fortunately provided.

Mr. DeCamp—Mr. Chairman, I want to correct Mr. Smith and also a wrong impression, perhaps on the part of others. In my statement that there were no light wires underground in the City of Philadelphia that were being successfully operated, I referred only to arc light wires. I think his Honor the mayor is entirely correct, that there has been enough done in the way of operating incandescent or low tension current to justify whatever doubt there may be in regard to it being resolved in favor of success. Mr Smith, in Philadelphia, is using a current of 1,000 volts, and at the February meeting in Pittsburgh I inquired particularly about that, because it was a matter of interest to me at that time, and I learned from Mr. Smith direct that there was a good deal less difficulty in insulating for that 1,000 volts than there was for a constant current of 2,000 volts. Now I went no further. I inspected Mr. Smith's and various other systems, and I have no reason to doubt, and it is confirmed by Mr. Smith now on this floor, when he says that they are using a wire for that current, which was put in there for a current of 200 volts, and are doing it successfully. I do not want any better confirmation than that. That does not come under the head of arc lighting, because of the low potential or the small amount of difficulty in insulating for that particular current.

I disclaim any intention of making any attack on the subway commission of the City of New York. I think they are making a great many mistakes. I have a perfect right to think that, and I have one suggestion to make for them, viz, that they go to work and secure an insulation—which has been suggested from time to time and to-day most forcibly by Dr. Moses—that will stand the currents that are used to-day for general public and commercial purposes. The standard to-day for that kind of work is, say, 3,000 volts. Treat it exactly the same as you would treat a steam boiler that you want to carry 100 pounds pressure; have the initial test made to 150. In securing your insulation for 3,000 volts give it the benefit of fifty per cent. increase. When you have secured that insulation then is the time to take up the question of subway, the question of conduits, the question of distribution. I would like also to make this suggestion: Is there a gentleman on that subway commission, or on the floor of this convention, who is prepared to say that when they accomplish the object I suggest that their whole scheme and system of subways will not be found to be entirely useless. The calculation of eight wires to a duct to-day is based on the insulations of to-day. If it is necessary to double or treble that insulation in order to secure it, it would reduce the capacity of that duct to one half or less. By the time they get through with that insulation perhaps they will find the whole thing useless, and they will have to have some other sort of system. Therefore, I think the time and money spent on the subway conduit is wasted.

Mr. Sunny—I should like to add something to what I said at Pittsburgh relative to the underground experience at Chicago. As you all know the arc light business at Chicago is all done through underground wires. The electric light companies never had any poles or wires in the streets, so that they never have been in the position in which the electric light companies in New York and Philadelphia are to-day. They started out with underground wires; they never had any other method of doing the work, and have had to do the best they could with the underground problem. We have done a great deal of work in that direction; it has been interesting, but it has been awfully expensive. About the latter part of last year all of the smaller companies were organized into the present company, the Chicago Arc Light and Power Co., and a new central station was built, into which all the circuits were carried. The conduit is filled up with wires insulated with Okonite, having an insulation of about 3-32ds. of an inch in diameter. Those wires were not used more than thirty or forty-five days, and were then abandoned because they burned out; but I ought to say in connection with that, that it was not any fault of the Okonite insulation; that company furnished those cables on the express understanding that the conduit was a perfect insulator, and that even a smaller insulation would have been large enough to carry the current of 2,250 or 2,500 volts. It was thought, after those cables burned out, that something to protect the insulation ought to be provided, and lead cables were selected having an insulation of the same size as the Okonite—3-32ds. of an inch. Those cables lasted about sixty days. and in January we had to pull them all out and throw them away, something like forty or fifty miles of them, and then we put in cables covered with lead, having an insulation of 6-32ds. of an inch. This is a paraffine insulation. The cables of 6-32ds. insulation have been in service about seven months. So far we have had four interruptions; that is four grounds have been developed in those cables. There are about 32 circuits carrying about 1,200 lamps. We have had four cases of trouble in those large cables. Of those four cases two have occurred in the Pittsburgh cable, and two in the Western Electric cable. We have been able to get at two of those pieces, one of the Pittsburgh and one of the Western Electric. We find that in one case the burn-out was caused by mechanical injury, and in the other by a discharge between the lead and the copper which burned out the cable. The other two cases we have not been able to get to, and we do not know whether they have been caused by mechanical injury or by the heavy current.

Now, while we do not feel that we have solved the underground problem we feel that the last six months has indicated that we are on the right track, and we are very hopeful that we have succeeded in finding a cable that will carry the current and give us permanently secure service.

With regard to the cost I have made a few figures that are very near correct, based on the experience that we have had. It costs us about $1,500 for putting in one circuit for two miles, one mile out and one mile back. That $1,500 includes the lead cable and the lamps. We are able to pull three cables into one duct of the conduit, and the charge for rental is a thousand dollars per mile per duct, so that each wire has to stand its proportion of the expense, which would be $333 a mile per year. Now it is very hard to tell, I cannot say with any degree of confidence, that those cables are going to last five years. They may last ten or fifteen; perhaps they will not last one year. We know nothing about that. But if they last five years we will have paid in rent $3,330, and the original expense of the cable of $1,500, a total of $4,830, which is $20 per year per lamp. I do not know what it cost you for aerial lines, but I think that you can count on a cost of from $18 to $20 a year per lamp on underground work.

Mr. Perry—I would like to ask Mr. Sunny if he is making any extensions of the Dorsett conduit.

Mr. Sunny—No, sir; we are not.

Mr. Perry—When you extend your conduit system what do you use?

Mr. Sunny—We are using iron pipes for the reason that our extensions are very small, and it is handy and quite inexpensive to put down. But if we were to make any considerable extension we would use Cyprus pump logs.

Mr. Perry—You are not afraid of their getting afire again?

Mr. Sunny—No, I am not afraid of that, because they become soaked with water, and I do not think there would be any danger of burning out.

Mr. Perry—Where you put three wires in a duct do you put positive and negative?

Mr. Sunny—We did put them in indiscriminately last year, but in putting in the new cables we have put the positive wires in one duct and the negative wires in another.

Mr. Perry—Where you cross the street do you use the concrete around your single iron duct?

Mr. Sunny—We do not. I would like to say, in connection with Mr. Acheson's paper, that we were very much interested, as you can readily believe, in finding out why it was those cables burned out. When we selected a 6-32ds. insulation to substitute for a 3-32ds. insulation, we did not know just why we did it; but we had to do something, and we thought if a 3-32ds. would burn out, and 4-32ds, of which we had a little, would not burn out except on rare occasions, that if we took 6-32ds. we would be pretty safe, so we took 6-32ds., and we have had only four cases of trouble. I made some experiments three or four weeks ago, and I am sorry to say that I cannot fully agree with Mr. Acheson in his explanation of why those cables burn out. As I understand, his theory is that where lead cable is used, the dynamic current passing through the copper conductors generates a static current in the lead, and after enough has been stored up in the lead a discharge takes place, which is generally through the insulation puncturing the cable. The experiments that were made were these: We spread out a piece of lead covered cable on one of the floors of the building. This cable was 960 feet long. We connected it to one of the arc circuits, making it a part of the circuit. We connected the lead—nine—which, understand, was perfectly insulated from the earth and from the proper conductor; we connected the leads with a condenser, and then discharged the condenser, and got a spark about 1-64th of an inch long, a spark which evidently would not jump through the finished insulation we have in use. We found, on examining the condition of the circuit on the outside with which this piece of cable was connected, that the insulation was something like a meghom. Then we took this piece of cable off the outside circuit and put it on what you might term an idle circuit, where the insulation may have been about five meghoms. We found that we got no noise and no discharge from the lead. The conclusion that we have reached in the matter is, that if you get your insulation on the outside up to a point above a meghom that there is not any danger of your lead cable; that there is no static electricity generated in the lead; but that if the insulation of your lead cable is low, if it is down to 250,000 ohms, which is practically a ground on one side, you get the thumping of the dynamo trying to reach a ground ahead of the resistance of the lamps on the other side. It seems to us that it is nothing more or less than liquid, practically and simply, without any static electricity to it.

Dr. Wheeler—I would like to ask Mr. DeCamp what he meant by stating, and he stated it very emphatically that the problem is not one of subways but of finding something to put in them, and if he meant that insulation could not be found, as far as he knew, which would answer in the subways, I would like to ask if the experience related by Mr. Sunny does not answer his question?

Mr. DeCamp—No, sir, it does not answer it. I refer entirely to the difficulty of insuring an insulation that will stand the current it is necessary for us to use to carry on the business that is now conducted; that is, a high potential current. I do not consider that that has been done successfully. When I say successfully I mean commercially successfully. Mr. Sunny is very fair in his statement. He tells you that he is not prepared to say that the last seven months' experience is evidence that his last effort is a success. Certainly his former efforts were not successful because he pulled all his wire out and put in new wire. Now do not make any mistake about it, because when you get that insulation, and if you and I live long enough we will probably see it, you will very likely find that all the provisions you have made by these subways are entirely useless for that particular kind of wire.

Dr. Wheeler—But don't you think that in view of the number of grounds they ordinarily have on overhead wires, that an experience of getting only four grounds on a large number of circuits is very satisfactory, especially for a place where this work has been tried for the first time? First work is always poorer than subsequent work.

Mr. DeCamp—I would consider four grounds on an underground cable equal to 400 on an overhead wire, because that is simply a matter of a few moments.

Dr. Wheeler—It depends a good deal on whether you are looking at it in the light of public safety, or in regard to keeping the lights burning.

Mr. DeCamp—That is the only thing that his Honor omitted to state yesterday with his usual clearness. He quoted to you the statistics as to the danger of electric light wires. It is so infinitesimal as compared with that of any other industry, that I do not think it is creditable for us to discuss it, but the question is a very serious one, when you get all your wires underground, whether wherever they do come above ground, the danger is not very greatly increased.

Dr. Wheeler—No, because the length of wires exposed, from which people get shocks, is very much less.

Mr. Acheson—I would like to ask Mr. Sunny what he refers to, when he speaks of the noise that he heard in the cables—the thumping?

Mr. Sunny—I ought to have explained that among the tests that were made after we discharged the current into the condenser and then discharged the condenser, then we connected a telephone into the lead on one side and a ground on the other and listened to the racket made by the Thomson-Houston machine. We got a tremendous racket. When there was practically a ground on one side of the outside circuit we could hear the noise for a distance of fifteen feet, but when we put this piece of cable on the house loop, the noise was practically nothing.

Mr. Acheson—It is quite evident that the difficulty he found in obtaining a spark was due to the want of a charge. You cannot get the discharge until you first have the charge, and the fact of his obtaining no noise was an evidence that there was no charge formed. If there had been a charge formed, you would have heard it through the telephone

Dr. Moses—Will Mr. Sunny please explain to us the data once more, so that we may be able to judge for ourselves, whether there was a charge or not? Just give us the conditions of the experiment. Will you please tell us what the object of the experiment was and what the conditions were under which the experiment was made.

Mr. Sunny—The conditions were simply these: This piece of lead cable 950 feet long, was strung out on the floor. The floor was perfectly dry, so that the lead was well insulated. We connected the lead to one side of the condenser. The other side of the condenser was connected to one of the copper conductors—perhaps I omitted saying that in the first place,—then we discharged the condenser and we got this spark of about 1-64th of an inch.

Dr. Moses—It seems to me from the conditions of the experiment that Mr. Sunny had only put together a rather elongated Leyden jar. The superficial area of the lead envelop was the equivalent of the exterior coping of the jar, and as he premised by saying that it was laid out on a dry floor, it shows that it was very well insulated and consequently could not fully discharge itself, or reaccumulate and charge itself, and that, thereafter he only got evidence from the electricity that had gathered on the exterior of the Leyden jar.

Mr. Weeks - Mr. Sunny stated to the convention, if I understood him correctly, that the cables that were first put in have all been withdrawn. Can you, Mr. Sunny, state to the convention the loss to your company represented by that experience—the loss of those cables, and the drawing-in of the new?

Mr. Sunny—I can only state the loss approximately. It is very difficult to arrive at any definite conclusion with regard to that, because it not only lost us the cables themselves, but it lost us the growth of the business we were sure to have; it lost us a reputation for service, and we lost in so many indirect ways that it is very hard to determine just how we came out. I should say, however, that the substitution of the cables, changing them three times cost us about $50,000

Mr. Weeks—How long had those original cables been in before they began to fail you?

Mr. Sunny—They were practically new. They were not in long enough to be at all acted upon by any excess of moisture underground, and I think it was purely a case of thin insulation. They had not been in more than four or five days, I think. I was not connected with the company at that time, so I cannot answer that question positively.

Mr. Weeks—I would like also, Mr. Sunny, if you will kindly do so, to have you state to the convention what the insulation of your circuit is by your daily tests. When I visited your station last, I found that you were making daily tests of the insulations of your circuits, and I found that about eighty per cent. of your circuits, on the occasion of my last visit were disabled, through the fact that their insulation was so low that you could not run on them. I think, if I remember correctly, some of them ran down to below 1,000 ohms.

Mr. Sunny—I would like to ask Mr. Weeks when he secured this information—about how long ago.

Mr. Weeks—About six months ago, when I called at your office.

Mr. Sunny—I can answer that question better, I think by quoting a remark that Mr. Haskins, the city inspector of the electric light, made a few weeks ago. We send him a report every Monday morning, showing the insulation tests of our circuits, taken the day before—Sunday. He has kept those reports, and he says he sat down and figured them up for several months, and that the average insulations of all of our circuits was 550,000 ohms; that those tests were taken on dry days, wet days and in all kinds of weather. The tests was invariably made Sunday morning, at about the same time, without regard to the condition of the weather. His figures were based, therefore, on an average running all the way through, and I think that it was a very fair average. Our circuits now measure a meghom in fully 95% of the tests. I do not know how much higher they measure because that is the capacity of the galvanometer used for that purpose. If they are a meghom we are satisfied. If they are below that, we go for them. We have still some Okonite and Kerite and

Bitite and other ite wires in service, and the low insulation comes in, in those wires becoming soaked with water and becoming crossed with some metal or some stone sidewalks.

Mr. Eustis—Is that insulation for a double circuit?

Mr. Sunny—That insulation is for a double circuit. There are thirty-two circuits; none are less than two miles and some of them are five.

Mr. Perry—Has there been any deterioration from the time you first placed these cables in your box to the present time? Have the cables individually, each one, held up to full standard, or has there been some deterioration?

Mr. Sunny—No, sir; there has been no change in those cables, with the exception of the four cases of trouble I have referred to. The insulation holds up first-class. With regard to grounds coming in on these cables, we do not look upon that as half so serious a thing as Mr. DeCamp does. When your circuit is started up, it measures a meghom or more. We do not know that the circuit is grounded until three or four hours before the next run or the next morning, so that that ground has not interfered with the service at all. Before it is time for that circuit to start up again, we have cut in a new section of cable to take the place of the defective one and are ready to start up without any loss of service. The expense of a case of trouble is the labor of pulling out a piece of cable and putting it back again. Under the manufacturer's guarantee, we get a new piece of cable to take the place of the defective one. That guarantee is three years.

Mr. Perry—At the end of that time you will pull them out at your own expense?

Mr. Sunny—I hope not.

Mr. Perry—I must say that, notwithstanding the fact that Chicago has been laboring so successfully with this matter for seven years, and notwithstanding the fact that they have, for the last seven months been operating beautifully, this thing is not ripe enough for me to pick.

Mr. Law—Mr. Sunny seems to think an underground wire is not a serious matter. We, in Philadelphia, have found it to be a very serious matter. I think when you have fifty or sixty lights burning, a ground has been developed, which may be in a section of wire, one, two, or three miles long. It is a difficult matter to look at that ground in your length of wire and get it out. You perhaps start up that night with a ground on your line. About eight o'clock at night, perhaps, the telephone rings and you are informed that the lights are all out on No. 5 circuit. The horse is hitched up and you go driving out on the street and you hunt for some time. You find the extremes of your ground, shut down your station and run a new line overhead between the lamps in order to make the connection. Your lights have been out all that time, perhaps one hour, two hours, or three hours, as the case may be. It depends altogether on how much time it takes you to put the wire up between the two lamps. Now I call that a pretty serious matter to have a whole circuit of lights out. Perhaps the whole circuit might not be out but a few minutes, but the lights between the two grounds are out all the time you are trying to get the circuit re-established. Now that was a matter that has happened to us, not once, but several times. I have had lights out on one circuit varying in number from fifteen to fifty-three lights, out for several hours during the evening; and the only way to fix those lights was simply to run an air line between the last two lamps. Fortunately the distance was not very great, and so we could do it very comfortably. Another section of cable two miles in length was grounded. In order to find that I had to make three cuts on that length of cable; I located the trouble in one length of 730 feet and procured a new cable. I pulled the cable out and found the burn perhaps 250 feet from the end, but in finding that, I also found that the lead on the cable was so honeycombed that it would be perfect folly to put it back. Therefore, I drew out the whole length of cable and put in a new one. In drawing that out, there was perhaps fifty pounds of sulphate of lead that dropped in the man-hole as we drew it out, showing the immense ravage that had been occasioned there. That cable had been underground about thirteen months.

Mr. Sunny—I do not wish to be understood as belittling the importance of keeping away from grounds or keeping them cleared up. Before we start out with our circuits, measuring the meghom, we cannot tell if a ground is developed on one side of that circuit unless the lights are reported out. I had reference more particularly to the four grounds in those new cables. In no one of the four instances did we lose any service on account of those grounds. It does not take more than an hour to change a ground on any one of our circuits, and when we were having so much trouble, we would perhaps have eight or ten cases of grounds in the morning, and we would generally have it all cleared up by three o'clock in the afternoon. We have a very good system in respect to that, and so far as losing service is concerned on account of those grounds, we do not look upon it as a very serious thing.

Mr. Weeks—The question of the loss of service is not the most important matter in connection with the ground. It is tolerably certain to occur however. You will lose your service, but there are other contingencies that may be very much more serious, for instance fire caused by a second ground or that ground, or injury to individuals. Our average insulation has been very much better than Mr. Sunny's in Chicago; but recently when we had a ground on one of our circuits, it so happened that a citizen of the city made a second ground. The result is a $10,000 damage suit.

Mr. Smith—I would like to ask Mr. Law if the second ground which cut his lights out occurred on the underground cable or on one of the aerial lines?

Mr. Law—It occurred on the underground cable. One case was at three o'clock in the morning, and the other, if I remember right, about nine o'clock at night. Our lamps are set on iron posts with a wooden block on the top to support the lamp. Under that wooden block is a terminal box in which that lead cable is inserted to protect the insulations of the lead cable. From that, we carry out Okonite wire to the lamp. A short circuit occurred in the terminal box between the wire and the lead, or between the wire and the case of the terminal box. In both cases, it burned off the wires—not only burned off the wires, but burned off the wooden blocks on the top of the poles, in one case dropping the wires and everything into the street.

Mr. DeCamp—I would state for Mr. Smith's information, that just before leaving home, I noted on the daily record of tests on the line Mr. Law refers to, which is about one-third aerial line, and two-thirds underground, that there were seven grounds reported during the month of August, up to the time I left, which was last Monday. They were all on the underground part of the circuits. There were no grounds on the aerial part of the lines.

The President—Gentlemen, the chair has given the widest latitude to this discussion, realizing that, not only the gentlemen present, but the people they represent, are vitally interested in this question, and not only they, but the public at large also, and the discussion this afternoon has been profitable in this respect. It has developed the fact, that while in Chicago and in New York city and in Pittsburgh, Philadelphia and other cities, they have claimed that there has been no progress and no efforts made by the electric light companies to solve this question, yet it has been demonstrated that these companies, individually, working alone from their different standpoints, have each taken up this question, and have attempted to solve it for themselves. They have not only done that, but they have communicated one with another, and obtained the best information they could.

When we first started to put up arc light circuits, we had a wire that every one now condemns. We forced the manufacturers into making these wires we are now using, when we showed them they had to do it, and we will go on and show our vital interest in this subject, by the appointment of these committees provided for in the resolution to-day.

This discussion has developed the fact that the gentlemen here in New York are going ahead, with the best knowledge and the best intelligence they have at their command, and they ask us as a representative body of men to start in and aid them as a body. We have never done that hitherto, but you gentlemen, in your resolution to-day, have provided for the continuance of the committee on the insulation of plant, and you have a vast amount of practical knowledge, as reported by Dr. Moses, to be collated and to be given to these manufacturers, and not only improve the condition of insulation, but improvement of the wire itself. You have gone further; you have provided for a committee of five, which shall collect data with respect to insulation from time to time, and report at the next convention six months hence what has actually been done, what are the practical results, what has been the cost, what it is going to cost, so far as they can find out. I say we are in the right direction. That leads up to another thing in my mind. It shows that you will need a permanent office somewhere where you can get this information, where it can be furnished, not only to the members of the association, but to the outside public and to municipalities and others who are clamoring for every one to go underground. I know if we could prolong this discussion, we could get more valuable information; but it cannot be done with the limited time at our disposal, and these New York gentlemen are so exceedingly kind in their attentions that they practically take up half the time of the convention. Of course we are very thankful to them. At the same time, that is the status of the case, and I am compelled to close the discussion.

The chair will name the committee on underground wire to-morrow morning. I will make one or two announcements. The first is that I shall appoint Dr. Liebig, of Baltimore, in place of Professor Thomson, on the committee on insulation and installation of plants. I want to say, gentlemen just here, that instead of members thinking it is no honor to be put on a committee of this kind, as might be inferred from the action of the committee hitherto, in simply reporting progress, that I should regard this as one of the highest honors that can be conferred on any member, and at the next meeting we will demand a report in writing from the committee, or know why they do not furnish it. They have reciprocal duties towards the association and if they do not intend to perform them, I wish they would so state when they are appointed.

Mr. T. Carpenter Smith—I believe an explanation is always in order, and I wish to make an explanation to the members

of the convention. In a letter which I wrote to a gentleman in this city, which was afterwards read to the board of electrical control, I made the statement that the inspector of lights in Chicago had shown a discharge from a magnet as an instance of an alternating current. I made that statement on the authority of a newspaper report of a lecture that he delivered. I received a letter from Mr. Haskins subsequently, imploring me not to put him down as an electrical idiot. I expected to meet him at this convention, when it was my intention to make a personal apology to him. But he is not here, and I know of no other way than to make my apology in the presence of this convention. I withdraw the statement then in the presence of this association.

Mr. A. F. Mason, chairman of the committee on revision of the constitution, presented as a report the following amended constitution:—The report was signed by A. F. Mason, G. M. Phelps, Geo. F. Porter, and Henry D. Stanley, committee.

(The amendments made by the convention to the draft of the constitution reported by the committee are incorporated in the text below, the corresponding parts of the committee's report being given in brackets.)

CONSTITUTION.

Article 1—*Name.*

The name of this association shall be the National Electric Light Association [The Electric Association].

Article 2—*Membership.*

SECTION 1.—Any individual or member of a company or firm operating an electric light, power, heat or welding station for public or commercial purposes; and any individual or member of a company or firm manufacturing electric supplies or apparatus, may become a member of this association by the payment to the treasurer of one year's dues.

SEC. 2.—Electricians, electrical engineers, and those whose profession or business is directly related to electrical interests or to the commercial application of electricity, may, upon the recommendation of the executive committee and a two-thirds vote of the association, become members thereof, by the payment to the treasurer of one year's dues.

SEC. 3.—Upon the unanimous recommendation of the executive committee and the approval of a two-thirds vote of the association, persons may be made honorary members of the association, with all the privileges of membership, except the right to vote.

Article 3—*Officers.*

SECTION 1.—The officers of the association shall be a president, two vice-presidents, a treasurer and a secretary, and an executive committee, to consist of the above-named officers, *ex officio*, and nine other members.

SEC. 2.—The president and vice-presidents shall be elected by ballot to serve from the close of the annual meeting at which they are elected until the close of the next annual meeting.

SEC. 3.—No person shall be eligible for the office of president or vice-president for more than two successive terms, but this shall not be construed to forbid the election to the office of president of one who has served as vice-president.

SEC. 4.—The secretary and treasurer, who may be one and the same person, shall be nominated by the president, subject to confirmation by the executive committee. The salary of the secretary shall be fixed by the executive committee.

SEC. 5.—The executive committee shall be chosen by ballot at each meeting, either annual, semi-annual or special, and hold office from the close of the meeting at which they are elected until the end of the meeting at which their successors are chosen.

SEC. 6.—The treasurer, secretary and executive committee shall make written reports at each meeting, which reports, upon their acceptance, shall be spread upon the records of the association.

SEC. 7.—The executive committee shall be the governing body of the association. They shall meet at the call of their chairman, from time to time, and shall report upon applications for membership, shall gather and prepare information upon topics of interest, and shall arrange for their discussion at the several meetings of the association. Five members of the committee shall constitute a quorum.

Article 4.—*Meetings.*

The annual meeting of this association shall be held in February, and a semi-annual meeting may be held in August of each year, at such places as the association shall determine, and on such dates as may be determined by the executive committee.

Article 5.—*Dues.*

The annual dues shall be $20, payable in advance, and shall cover the calendar year.

Article 6.—*Ballot.*

On any question before the association a ballot may be demanded by ten of the members present [one-fourth of the members present].

Article 7.—*Amendments.*

SECTION 1.—Amendments to the constitution shall be presented in writing, and referred to a committee to be appointed by the chairman before being acted upon by the association; a two-thirds vote of those present shall be necessary to their adoption.

SEC. 2.—No amendment shall be voted upon on the day of its first presentation.

The constitution as above printed was adopted, and the committee was discharged with the thanks of the association.

The convention then adjourned until the following day at 10 A. M.

THIRD DAY'S PROCEEDINGS.—FRIDAY MORNING'S SESSION.

The President—We will open our proceedings this morning by taking up the reports of the various committees. In the absence of the secretary I will state in a few words the report of the transportation committee. They made every effort to obtain a reduced rate to this meeting but they failed in their efforts although various promises had been made to them. They now have a letter signed by Mr. Daniels promising that if the next meeting shall be held west of Pittsburgh the railroad association will give a one and a half rate for the round trip. That may be considered as the report of the committee on transportation.

On motion, duly voted, the president then appointed as a transportation committee for the next meeting George F. Porter, of Philadelphia, chairman, Morris W. Mead, of Pittsburgh and F. E. Degenhardt, of Chicago.

The committee on the New England Insurance Exchange, Mr. Frank Ridlon, chairman, reported as follows:—

REPORT ON THE NEW ENGLAND ELECTRIC EXCHANGE.

Mr. President and Members of the National Electric Light Association:—

I beg to submit to you the report regarding the New England Electric Exchange, as requested by the chairman of your committee, at the last meeting of that committee. This subject was first thought of and talked about at the electric light convention held in Baltimore, in February, 1886, and has several times been referred to since; but only in March of the present year did it assume any business form. On the date referred to, the Boston Electric Club sent out a notice asking the various electric light companies or their representatives in the New England states, to meet together at the rooms of the Boston Electric Club, that we might discuss the relations between us and the New England Insurance Exchange, representing the insurance interest of the New England states. Added discussion of the difficulties then existing, or that might exist, between the electric light companies and the telephone and telegraph companies—these matters having been fully discussed in the afternoon and evening sessions—led to the formation of the New England Electric Exchange, which consists of a president, vice-president, and three directors. Since the first meeting, we have held one regular meeting of the exchange, on a date provided for in our constitution, and the president, secretary and directors have met from time to time, formulated a constitution and by-laws for governing the exchange, copies of which I submit, and appointed examining boards for the purpose of examining applicants for licenses; and have now five boards, consisting of three examiners each, to attend to that part of the business. These examinations have been faithfully carried out, and some 50 applicants have passed the examination required, and have, or are about to receive their licenses for such a class of work as they were found competent to do. We have been ably aided by those who we may now term our friends, the officers and members of the New England Insurance Exchange. They first encouraged us by offering a reduction in insurance where buildings were exclusively lit by electricity, and also where power was furnished from the same source. Lately they have issued a notice, stating that on and after the first of October, they would cease to issue permits for insuring buildings where electric lights were in operation, unless the party operating the plants should hold a license from the New England Electric Exchange. In addition to this, they are about to carry into effect a personal notice to all central stations, the same to be carried out in a personal interview between their representative, Mr. Brophy, and the party in charge of the central station, wherever the same may be located in the New England states. I believe that the success of this organization, depends on the thoroughness with which the business as set forth, shall be carried out; and that part having been accomplished in a thorough and satisfactory manner, it will not only advance the interests of electric light and electric power as a whole, but will free us from those petty annoyances and uncharitable remarks which are often given to different systems; being almost wholly brought about by want of proper care in constructing and maintaining plants. This may sometimes be due to carelessness, but more often it is a case of want of knowledge by the operator; who would gladly seek that knowledge, had he any means of obtaining it. As that knowledge has become a necessity, it would seem to be a duty for us to establish schools and places of instruction

in our large cities, where intelligent workmen may seek and obtain the information they wish. This can easily be done in our electric clubs where we have the books and periodicals, with everything relating to the rapid advance of the business. Also able instructors in our members, who would be perfectly willing to devote one or two evenings in a week, during the coming winter, to the instruction of those who may wish to increase their knowledge of the business, to which they intend to devote their energies. These schools added to the scientific lectures and reading of papers on electrical subjects, which were so much credit to their writers during the past winter, will very largely aid in bringing forward our young men, and give them that practical experience, which joined to the technical knowledge they may have obtained, would bring about that degree of perfection which would promote confidence with the insurance people as to the ability of those employed in electric light stations ; and last but not least, satisfy the capitalist that the money he has risked in carrying out electrical enterprises, will be judiciously and intelligently expended. FRANK RIDLON.

On motion, the report was received and ordered filed, and the committee continued, to report any further information they may get on the subject at the next meeting of the association.

The President--The chair announces as the committee, proposed by Mr. Lynch yesterday, to obtain practical information in regard to underground conductors, E. T. Lynch, Jr., chairman, C. H. Barney, F. B. Crocker, C. H. Davis, and Walter C. Kerr.

Mr. Steuart—Yesterday at the close of the discussion upon underground wires and underground conduits, there seemed to be an absence of point to the action of the association, and some of the members considered that it might be well to put the matter into some definite shape in order that the public might know what we did think upon this subject; I have, therefore, drafted the following resolution and would offer it :

"*Resolved*, That the National Electric Light Association after a full discussion of the subject, desire to express their hearty sympathy with the views expressed by his Honor, Mayor Hewitt, in his address before the association upon the subject of putting wires underground, and in addition desire to take this mode of expressing the opinion that up to the present time no commercially practical method has ever been brought to their notice by which high tension direct currents such as are used for arc lighting can be placed underground."

The resolution was seconded by Mr. Lynch and carried.

A paper on "The Comparative Danger of Alternate vs. Direct Currents," by Professor P. H. Van der Weyde was read by Mr. Arthur Steuart.

THE COMPARATIVE DANGER OF ALTERNATE vs. DIRECT CURRENTS.

BY DR. P. H. VAN DER WEYDE.[1]

IT is only a few days ago that I received the flattering invitation to appear before this meeting of the most eminent electricians of the United States, and present a paper containing my conclusions about the comparative danger to life lurking in the alternate and direct dynamo currents. I do so readily, as I have lately had the opportunity to become acquainted with the arguments made on both sides of the question. I was not prepared to do so when, a few months ago, I attended a meeting of the New York Board of Electrical Control, where several papers were read, most of them in opposition to Mr. Harold P. Brown, who had expressed himself against the use of the alternate current system, of which the introduction has lately been commenced. When the president of that meeting asked me to express my opinion I was in the necessity to decline, stating that my appearance there was solely intended to listen to arguments upon the subject about which I desired full information.

As some of the papers read there were written in such a spirit as to compel Mr. Brown to defend himself, I made up my mind to attend his expected defense, especially as it might give me an opportunity to hear what powerful arguments and facts would be brought out by the person who has put himself forward as the champion of the enemies of the alternate current system.

It makes always a painful impression upon me when I see that a scientific investigator feels the necessity to defend himself against personal attacks. The calling of the scientist should simply be confined to ascertain what is the truth ; if he thinks to detect erroneous conclusions arrived at by any colaborer, it is his duty to expose them. At the same time we must mind the old rule, *suaviter in modo, fortiter in re ;* therefore, above all he must let the facts speak for themselves, avoiding any allusion regarding the capabilities or ulterior motives of his antagonist ; in short, he must leave the use of all personalities to the politicians ; for these the main considerations are *persons*, *principles* are secondary and may be changed to suit circumstances, or thrown overboard entirely. In science, however, we have to the contrary nothing to do with *persons*, but only with the ultimate *truth*, which we are all striving to arrive at.

At a recent visit to the physical lecture room of Columbia College, where I had been invited by telegram to hear the reading of a paper, and a lecture illustrated by experiments by Mr. Harold P. Brown, the feeling referred to above was more painful to me than even the howling of the dog which was experimented upon. Dogs have for so many years been considered as the poor legitimate martyrs of science, especially under the hands of physicians and professors of physiology, that we have become more or less hardened in their regard. Nobody will deny the immense value of the increase of our biological and especially pathological knowledge obtained in this way.

A great portion of the paper read by Mr. Brown, consisted in complaints about the personal attacks made upon his capability, as soon as he asserted in print that the alternate electric currents were more dangerous to human life than the direct currents, namely : that a current of the electromotive force of say 300 volts, alternate current, would be more likely to destroy life than double or triple that strength of a direct current.

One feature was prominent in the reading of the paper as well as in the lecture and experiments ; it was evident that the purpose was not so much to exhibit what was the truth in the matter as to show that he was right in what he had asserted.

He attempted to prove this by experimenting upon a large dog, which, when subjected to a direct current, stated to be 300 volts, set up a short howl ; 600 volts produced a longer howl and frantic efforts to escape from the cage, while a current of some 900 volts paralyzed the dog, who kept up a labored breathing. Then a representative of the New York Society for the Prevention of Cruelty to Animals interfered, and forbade further trials of this kind, so that Mr. Brown was compelled to give the dog the *coup de grace* by applying the alternate current, which he stated to be of the strength of only 300 volts.

Unfortunately for Mr. Brown this proved nothing, as the dog was already half dead by the previous successive and increasing direct current doses of 300, 600 and 900 volts respectively. Another dose of 300 or 600 volts direct current might, in all probability, have ended his life just as well. But what is more, his statement that the alternating current was merely 300 volts was not proved, as he himself had stated previously that reliable instruments for measuring alternate currents were difficult to obtain, and confessed that he had only a voltmeter for this purpose but no ammeter. After the lecture I examined the voltmeter, and found that according to the statements of Mr. Brown, its operation was based upon indications of rise in temperature.

Now, it is well known that rise of temperature is not produced by electromotive force, but by amount of current ; one Wollaston plunge battery cell, of one square meter acting surface, having, of course, the electromotive force of only one single volt, will produce far more heat

1. The unavoidable haste with which this paper was prepared resulted in a few inaccurate deductions, based on certain superficial examinations. Some of these were corrected in the paper as read, but unfortunately not incorporated in the weekly electrical journals, which in their praiseworthy endeavor to give an early report of the meeting, had the first half of the paper in type before it was read, and could not detain their publication to make the corrections referred to as fully as desirable.

The ELECTRICAL ENGINEER being a monthly publication, allows time for correction, and having adopted the excellent plan of submitting the proofs to the writers for ultimate correction, I take advantage of this opportunity to obtain a more full and correct record of my paper as I intended it to be.—P. H. VAN DER WEYDE.

than a series of 24 freshly prepared cups of a Leclanché battery of 40 volts electromotive force. This voltmeter was perhaps a kind of ammeter.

This was the opinion of Professor G. Forbes, from England, who last year exhibited to the Society of Electrical Engineers, in New York, a meter for alternating currents; he did not call it a voltmeter, because its operation was also based upon rise of temperature, but he called it a current meter. This meter was described and illustrated on page 1, of the *Electrical Review*, for October 8, 1887, where there is added a little table giving the observed currents in amperes. Immediately under that table follows the statement that Sir William Thomson complimented the author on having practically solved a problem on which he himself had been working without satisfactory results, thus endorsing the instrument as a current or ampere meter.

If, however, such an instrument is carefully gauged in regard to resistance, so as to satisfy the formula volt = am. × res., it may be converted into a voltmeter; but instruments of this kind are not always properly gauged in this way, and are frequently unreliable.

And here I cannot let the opportunity pass by to repeat what I have been preaching for years, namely, that the voltage alone is no criterion in regard to the dangerousness of a current; the danger comes only when the electromotive force (as measured in volts) is accompanied by a sufficient quantity or volume of current (as measured in amperes). An electromotive force carrying a current of only a few micro-amperes may be as high as 1,000 volts without doing any harm (even when alternating, as proved by the Rhumkorff coil). It behaves like water oozing out of a pinhole under pressure of hundreds of pounds; it can do little or no work. At the other side, a very large volume or quantity of current with small electromotive force, of say a small fraction of a volt, will not have the power to pass through the human skin, or even through the liquids of the body, but only through metals (as proved by the thermo-electric pile). Such currents behave like a large volume of water in a lake, with little or no inducement to make it move; also, this will do little or no work.

Professor Mayer, of the Stevens Institute, Hoboken, in a lecture recently given to the members of the electric section of the American Institute, exhibited some novel experiments, intended to measure, if possible, the voltage of static currents. He used an old-fashioned friction electric machine, and showed that the voltage of its currents ran into the thousands, while the amperes were so minute as to escape the possibility of measurement, with the means thus far at disposal.

This leads me back to the subject of the experiments of Mr. Brown; he stated that the quantity of the direct current he used was only a fraction of one ampere. This induced me to examine also the ammeter after the lecture, when I found that the ammeter and voltmeter were coupled together in series in the same single circuit. I did not see any switches connected therewith, so as to shunt out the high resistance of the voltmeter when the current was applied, as is frequently customary; therefore I concluded that the direct current had the benefit of being moderated by this resistance also, which benefit was not given to the alternating current for reason of the absence of this high resistance in its circuit, and in place, therefore, the much lower resistance of the alternating ammeter referred to above. When after the lecture I visited the dynamo plant of Columbia College to inquire, I found that the direct current machine used was an Edison municipal dynamo of 15 amperes and 1200 volts.

It is likely that Mr. Edison gave it the name of municipal in anticipation of the fact that the municipal governments will need such machines when the new law in regard to capital punishment and of despatching criminals by electricity instead of hanging goes into operation next year. If so, it is very suggestive, in regard to the controversy we are discussing, that such an able electrician as Mr. Edison is satisfied that a direct current dynamo is all that is needed for that purpose without regard to the alleged greater effectiveness in this respect of the alternate current dynamos.

This dynamo did not belong to the Columbia College plant, but it was furnished by Mr. Edison for the occasion, as well as an alternate current dynamo. Both were removed after Mr. Brown finished his experiments, which, it appears, he continued privately for a few days after the lecture.

One of the dynamos used belonged to the college plant; it was an incandescent light dynamo, of which the capacity was stated by the engineer to be 125 amperes and 110 volts. This dynamo was employed to obtain the alternate currents, by using it to feed the magnets of a Siemens-Halske alternate current machine after the usual manner, as represented in the engraving, exhibited here, which shows the essentials of the arrangement used, only with this difference, that the field magnets of the Siemens alternating machine were supplied by the direct currents obtained from the much larger 125 ampere dynamo referred to, in place of the small one represented in the engraving, at the right hand side below.

The kind of apparatus which was used and the nature of their arrangement, for the production of the alternate current, makes it very unlikely that it would not produce a considerable current. Especially when we take into consideration that the current developed must represent some kind of equivalent for the horse power required. Firstly to drive the 125 ampere incandescent light dynamo, next, that required to drive the alternate current dynamo; the latter must have consumed considerable power, as the 125 ampere current was more than sufficient to saturate its great number of stationary electro-magnets. According to the statement of the engineer, the engine driving the 125 ampere by 110 volt dynamo was of 36 h. p., but as this dynamo furnished only 125 x 110, or 13,750 watts, its duty, theoretically considered, amounted to the consumption of 19 h. p., so it appears that not as much as 36 h. p. was consumed. If we make allowance for the ratio of useful effects of Edison's dynamos as determined at the Philadelphia electric exhibition to be 90 p. c., we will not be far from the truth if we assume that this dynamo consumed 21 h. p. In regard to the alternate current dynamo, we may arrive at an estimate by knowing the fact that the other steam engine which previously drove the direct current municipal 1200 x 15 or 18,000 Watt dynamo, consumed theoretically 24 h. p., but making again allowance for the 90 p. c. useful effect as before, we obtain nearly 27 h. p. As it appears that this very steam engine drove afterward the alternating current machine, with the same velocity and steam pressure, we obtain the total amount of 27 + 21, or 48 h. p. required for the generation of the alternating current. This corresponds to the production of 35.808 watts. Assuming a current strength of 30 amperes, it would give 1,193 volts, for 15 amperes 2,387 volts.

Of course, this is an exaggerated estimate, but sufficient to show the underestimate of the figures as given by Mr. Brown. In order to come to correct conclusions it would be necessary to measure, by means of indicator diagrams, the engine power utilized, and measure the currents obtained by proper instruments, properly used and conscientiously observed.

But in fact it is scarcely necessary to go into any calculation to make it evident that the alternating current obtained must have been double that of the direct current, when we consider that for the direct current one steam engine and one dynamo was used, while for the production of the alternating current two steam engines and two dynamos were employed.

One thing is certain, namely, that the dynamos used were not of such a defective quality as to warrant the

supposition that this would not be the case, and the acknowledged absence of proper measuring instruments for alternating currents, connected with the fact that the estimate of the current strength which was switched in the circuit applied, appear to have been based upon the same amount of rheostat resistances, as had been used for the direct current, makes it very probable that the voltage of the alternating current was twice as high, if not more, than estimated by Mr. Brown.

There was added on the lecture room table another important additional (however small) contrivance, for the right understanding and use of which I will have to make a short introductory explanation. I do this also because I have been especially requested to do so, by several parties who had become interested in the operation of this, to them, very novel device

I must ask pardon for bringing some elementary considerations before this learned body, but my apology is that this paper will be published and read by many who are not so well informed about electrical subjects, and whose ideas upon it, need some clearing up.

Every one who has handled faucets attached to pipes from which water can escape under pressure, will have noticed that when suddenly shutting off the water, a blow like that of a hammer is produced in the pipes. This is caused by the momentum of the water when in motion (often very improperly called inertia), and which shows itself every time this motion is arrested. On this peculiarity is based a contrivance in which, by the automatic alternate opening and closing of a valve, a small portion of the water discharged may be raised to a greater height than that of the original device which produced the pressure. This contrivance has been called a hydraulic ram, and by its help an increase of pressure may be obtained at the expense of a certain quantity of water.

Notwithstanding electricity is not a fluid like water, it behaves, however, also in this case, in a similar manner; at the moment a uniform electric current is suddenly interrupted, a current of greater electromotive force (more pressure) is developed in the conductor, and will show itself as a spark at the break of contact, and as a shock through the body when the hands have hold of the wires when the contact is broken. It is a very old observation, and one of the earliest reminiscences of my boyhood (about 1823), that the current of a column of volta of say 30 pairs of plates, scarcely perceptible when closing the circuit through the body, will give quite a sensible shock when breaking the circuit. Such currents have been called extra currents, and they are, of course, stronger in proportion to the strength of the original current, and still further increased by inductive influences when there are coils in the circuit.

As it may be desirable for special purposes to eliminate these currents, an apparatus has been invented, which operates like a very sensitive relay, and then leads these extra currents off, or shunts them into another channel after the manner of lightning protectors. Such an apparatus was on the table during the experiments with the dog, and appeared to be intended to protect the animal against the effect of these extra currents. I must confess not to see why this was done, except for the purpose to annul the most powerful and most dangerous items connected with the direct current. Therefore, I consider the addition of this contrivance improper if we wish to arrive at the truth in regard to the comparative danger of the alternate and direct currents, because in case of accidental exposure of person, there is rarely such a safeguard inclosed in the circuit, and the person struck by the current must submit to the extra current as well.

In order to arrive at the truth of the matter we must also, above all, be able to make definite statements about the voltage and the volume of current, based on precise measurements, which, in regard to the alternate currents, could not be furnished but was only guessed at.

Finally, as far as I can judge about the matter, guided by the present state of knowledge (especially in regard to some, in many respects, still unexplained peculiarities in the behavior of alternate currents), I should say that their true voltage must be quite high. They do not behave like currents of low voltage (say 300 or 400) as they can be, and practically are, conducted over much longer lines and thinner wires than is the case with the direct currents of say 1000 volts. This fact is acknowledged as well by the enemies as by the friends of the alternating current system. Experiments made with converters, especially with a new and very peculiar one of my own construction, appear also to show that there must be considerable voltage in the alternate currents so as to account for the generation of the enormous volume of current into which the electromotive force is converted; in other words, for the thousands of amperes obtained by the conversion of the volts of the primary current, and for which amperes there is no ammeter yet to measure them; but their volume shows itself in the capacity to perform operations requiring the highest temperatures, such as welding iron, fusing the most refractory substances, &c.

Surely no dynamo could be constructed directly generating a current of such volume as it would destroy itself by the heat of its own current; it is only by alternating current machines of high voltage, assisted by proper converters, that currents of such great volume and high caloric capacity can be obtained.

I am satisfied that the alternating current dynamo has a great future before it, not only for electric illumination, but also for motive power, metallurgical and probably even electrolytical operations.

After all, we must not lose sight of the main objects of this controversy, which is the comparative danger lurking in the two systems. Were it found by experience that actually, the danger of being killed is greater by the use of alternate currents, it does not make any difference if the voltage which does the killing is 300 or 1300.

When, however, we consider that statistics show that the loss of life by the direct current system is continually increasing in proportion that the system is extending, the probabilities appear to be that both systems will furnish their equal quota of victims, and the labor of comparing the relative danger of both systems, and especially the discussion about their comparative voltage, appears to become an idle occupation.

Those who favor the burial of all electric light wires underground out of sight, overlook the difficulty to keep them out of reach also; namely, at their connection with the overground lights. This is no doubt easier with the existing system of overhead wires when placed all out of reach, while the sufficiently protective insulated covering may as well be applied to such wire, as is the case with the underground lines.

The agitators who want legislative interference against the use of high tension dynamos, should be consistent, and if the protection of human life *is their real motive*, they should attempt to obtain also legislation against the manufacture and use of high tension dynamite, nitro-glycerine, and other similar explosives; also against the use of gasoline lamps, burners and stoves, all of which produce almost daily their quota of victims. Further, against horse and foot races, rowing and swimming matches, base and foot-ball games, athletic sports, etc. Each of these have from time to time produced more accidents and loss of life than is the case with the electric light currents, about which it appears to be the fashion to make a great fluster when occasionally a life is lost, while the killing of a base ball player or jockey, attracts scarcely any notice.

The opposition of the alarmists who predict terrible disasters from the introduction of alternate electric currents, reminds me forcibly of the predictions made less than one century ago, when the world was warned against the intro-

duction of illuminating gas and railroad trains. About gas it was prophesied that it would blow up cities, or destroy them by universal conflagrations, and that railroads would cause the indiscriminate and wholesale slaughter of the reckless individuals who dared to tempt Providence, by trying to travel with the enormous velocity of 20 miles an hour. But the gas and the railroads have come to stay, and so will the high tension currents. The progress of the world cannot be impeded and much less arrested by a few timid alarmists.

DISCUSSION.

Dr. Moses—That very interesting paper calls to our attention some experiments which were made at Columbia College. However, I would like to warn you, gentlemen, that those experiments were not made by the professors of Columbia College but by a set of self-constituted investigators, who have tried to frighten the public, and by holding up a terror before them to scare them into a certain course. I think that one of the most beautiful passages I ever read was in that novel of Bulwer's, where he describes the perfect peace and calmness prevailing at Pompeii before the eruption and destruction of the city. We have been sitting here as a sort of mutual admiration society, taking in all the compliments, well meant and many of them true, of so wise a man as Mayor Hewitt. But, gentlemen, something has happened to-day which I think ought to be called to your attention, so as to awaken you from your lethargy, and I will read a passage from a letter in which a note of attack is sounded, which I think we ought to meet with serried ranks. This is a letter from Ex-Governor Cornell to Mayor Hewitt. I quote it as printed in one of the daily papers, and I am told it is the entire letter, with the exception of five unimportant lines :—

"The disposition of electrical wires in such manner as to abate their dangerous qualities, and at the same time to preserve their useful features, is a question demanding serious thought and urgent remedy. It has long vainly sought solution, and you are the man who can apply the true and only available corrective. The only remedy now practicable for removing the danger of high tension circuits, which presently menace the life and property of our citizens, is to absolutely prohibit their use within the city; the strong arm of the state by legislative enactment and honest executive administration of such law positively prohibiting the use of wires bearing the high tension circuits will give us safety. Nothing else can so quickly and surely accomplish it. Will you help us to this result?"

The President—I would like to know if Ex-Governor Cornell writes that letter as an expert or as a representative of the Western Union Telegraph Co. or some other interest.

Dr. Moses—We all know that Ex-Governor Cornell is largely interested in the Western Union. We also know his ability and his great influence, and when such a man speaks we must listen and reply. Gentlemen, I have prepared a set of resolutions that I think this association ought to promulgate for their own safety, recollecting the fable in Æsop where the bulls, when they kept together, could keep off the lion, but the instant they separated they were devoured by him. The effort is made to destroy one of the important interests which it is the duty of this association to foster. I call your attention to it and warn you. Gentlemen, this is the resolution :

"*Whereas*, The National Electric Light Association view with some uneasiness the persistent efforts of rival interests to educate the public to distrust of high potential electric currents ;

"*And whereas*, They would protest with all energy against recent efforts to pit against each other the continuous and alternate current systems of electrical distribution, which efforts had as their covert purpose the destruction of the harmony of action now existing between them ;

"*And whereas*, This association, for mutual protection, recognize distinctly the danger of unfair legislation, such as has destroyed the electric light interests of Great Britain ;

"*Therefore, be it resolved*, That the National Electric Light Association emphatically declare that it is beyond a doubt possible to produce and distribute high tension currents for public use without any more danger or difficulty than attends the distribution of gas and water in our dwellings.

"*And further be it resolved*, That they would impress all legislators with the fact that success in the electric light and power business is based chiefly upon economy in the size of the distributing conductors, and that to utilize this fact high tension current were adopted in the first stages of development of electric lighting, and have been used ever since, and will continue to be used ; and further,

"*Be it resolved*, That it is our conviction that there is no difference in the dangers attending the use of continuous or alternating currents, and that both may be so transformed before being used as to render them a perfectly harmless and practical means of distributing electric power for use in cities."

The adoption of the resolutions was moved and seconded.

Mr. Steuart—This is not a time when it is desirable to harp upon a political issue; but it seems that the policy that is prevalent throughout the country is one that should guide us in adopting these resolutions. The protection of American industries is one of the things which is exciting the public mind. The protection of one of those industries is one of the things for which this organization was formed, and one of its greatest elements of usefulness. I can speak from the observation of my friends in England, who have told me of the very great depreciation of the electric light business which has been the result of adverse legislation in that country towards electric lighting. The gas interests there are very powerful, and they have succeeded in so influencing Parliament as to secure the passage of laws, which for the past ten years have crippled the industry which has grown to such proportions in this country, and I hope that this association will put itself upon record by adopting these resolutions, as opposing any such policy, and as stating to the world our view of the subject, as those who have had the most experience, and the most practical experience, in handling this class of business.

Mr. T. Carpenter Smith—There is one feature of the legislative interference with the electric light business in Great Britain which I think deserves our very serious consideration. We have been reading, I have no doubt all of us, in English journals descriptions of English installations, and a good many criticisms have been passed on the other side of the waters about the flimsy method of installation which prevailed in this country. Now, the fact that there has been very little work done in England, is very clearly to be attributed to the adverse legislation, and as a consequence of that the few installations that are being operated to-day are being operated in a most reckless manner, such as would not be tolerated in this country. As an instance of that I would mention the fact stated by Mr. McKenzie, I think at the meeting of telegraphic engineers there, in reference to the system in the Grosvenor Gallery, that he had as many as six buildings cut out by the grounding of wires on the gas pipe fixtures, and he recommended that the chandeliers, if they had to be used for electric lighting, should be insulated in that way. I don't know how many years it is since we were ordered to put in insulating joints on all lines; but that in 1888 is the condition of the electric light in England, and it is a striking commentary on the effect of adverse legislation. The more the electric light is used the more precautions will be taken with it; for the public are your customers, and unless you protect them you will ruin your own interests.

Mr. Lynch here read, for the information of such members as were not present at the time Mayor Hewitt delivered his address, that part of his Honor's remarks wherein he referred to the sensational articles appearing in the newspapers with respect to the dangerous character of electric light wires.

The resolutions proposed by Dr. Moses were then unanimously adopted.

Dr. G. A. Liebig, Jr., then read the following paper :—

SOME METHODS OF ELECTRICAL MEASUREMENT.

BY G. A. LIEBIG, JR., PH. D.

AMONG the requirements of modern electrical engineering and the usual practical work in electricity is the ability to make accurate and reliable measurements of current, of potential, of capacity, etc. And with the growth of practical electricity itself goes hand in hand the increasing necessity of instruments of precision and standard apparatus with which the various appliances in every-day use may from time to time be compared.

It may not be out of place, therefore, to give a brief account of some methods of measurement and comparison, many of which have been thoroughly tested, and one or two of which are believed to be new and more reliable than the methods hitherto applied. Let us discuss first of all the best manner of measuring *currents*.

Current determinations may very conveniently be divided into two groups, *i. e.*, the measurement of heavy currents, and the measurement of small currents. Of the latter very little need be said, as the best method undoubtedly depends upon the use of an electro-dynamometer, and the most suitable form of such an instrument is that of the British Association, the well-known Weber electro-dynamometer, which has been thoroughly explained and mathematically treated at length by Maxwell. With two or more electro-dynamometers of this kind, currents, ranging from a few mille-amperes, to 10 or 25 amperes, can readily be measured with an accuracy of one part in two or three thousand. Currents greater than this must be determined by some other arrangement, since a dynamometer capable of accurately measuring very heavy currents would have to be of

massive proportions and of correspondingly increased cost. An instrument at the Johns Hopkins University, which is intended to measure currents up to 15 amperes, has fixed coils one meter in diameter.

For heavy currents it has been found advisable to apply the method of "fixed resistances," a method which has been used and successively improved in several electrical exhibitions in this country and abroad, and the range of which is practically unlimited. In this method the current to be measured traverses several heavy german-silver bars which have been hard soldered to a pair of very large copper blocks to which are fastened, in the same way, the terminals of the galvanometer leads. The bars and end blocks are immersed in a tank of refined petroleum, and their temperature, by stirring constantly the oil, can be determined to a few hundredths of a degree. To use this apparatus a known current, measured by an electro-dynamometer, is sent through the fixed resistance, and the potential at the ends determined by the galvanometer joined at these points. The deflection of the latter corresponding to any other current, gives us at once a measure of the current. In practice a resistance box is placed in circuit with the potential galvanometer, and the resistances always adjusted until approximately the same deflection is obtained. By doing this we render ourselves independent of the assumption that the angular deviation of the galvanometer needle is proportional to the current, except for exceedingly small differences. It is to be noticed, however, that the calibrating current is measured by an electro-dynamometer, and not by a galvanometer, the reason being that the former is independent of the value of H (the earth's horizontal component), whereas any error in the determination of H appears directly in the galvanometer constant.

During the measurements the oil in the tank is constantly stirred and its temperature noted. As a matter of fact this is found to change but little even with currents of 200 amperes or more. Calling R° the resistance of the german-silver bars at 0° C; β, its temperature co-efficient; T^1 and T^2, temperatures of the same corresponding to currents C^1 and C^2; D^1 and D^2, r^1 and r^2, and t^1 and t^2, the deflections of galvanometer, adjusted resistances, and their temperatures, corresponding to current C^1 and C^2, we have

$$C^2 = C_1 \frac{D^2 (1 + \alpha\, t^2)\ \surd^2 .\ R^\circ (1 + \beta\ T^1)}{D^1 (1 + \alpha\, t^1)\ \surd .\ R^\circ (1 + \beta\ T^2)}$$

α being the temperature co-efficient of the resistance box. The terms relating to changes of the resistance R°, *i. e.*, of the german-silver bars, can generally be neglected.

POTENTIAL MEASUREMENTS

can be made in exactly the same general manner, the "fixed resistance" used for this purpose being, however, very much higher. A known current is passed through the german-silver reel, forming the fixed resistance, and the deflection of the galvanometer, joined to its ends, is noted. A resistance box in circuit with the galvanometer enables us to reduce this deflection to a convenient angle. Care must be taken that the current used for calibrating the galvanometer be so small as to heat the fixed resistance as little as possible. After the calibration is completed, the galvanometer is joined to points whose electromotive force we wish to measure, and the resistance box adjusted until the same deflection as before is secured. We have then, an expression for the potential, of exactly the same form as the one given before. For very high potentials the method is inapplicable, and recourse must be had to an absolute electrometer of the kind first described by Sir Wm. Thomson. In this instrument, fully explained in Thomson's papers, the difference of potential between two points is measured by the attraction between two discs electrified to the same difference of potential, one of them being balanced by a series of weights, the other being fixed. With such an instrument electromotive forces varying from 1,000 volts to over 100,000 volts can easily be measured, and it thus offers an excellent means of comparison with electrostatic voltmeters, etc.

There is perhaps no better way of measuring *resistances* than by the employment of some accurate and sensitive form of Wheatstone bridge. The only difficulty encountered in such measurements is the exact determination of the temperature of the various resistance coils and standards in use during the work. It has been found absolutely necessary to immerse all the measuring coils in liquid during the use of the apparatus, and to allow them to remain in a room whose temperature is almost constant several hours before any measurements are made. Even thin glass tubes, containing mercury and surrounded on all sides with cracked ice, have been found to require at least five or six hours for their temperature to fall to zero.

The efficiency of dynamos and motors can be determined with all necessary accuracy by means of any one of several dynamometers of distinct types, and now well known, and the subject is one which presents no difficulty whatever until the attempt is made to measure the efficiency of very small machines; that is, machines of one horse-power and less. In these cases it has become necessary to devise a way of measuring which shall greatly reduce errors ordinarily encountered. The difficulty generally presented is that the dynamometer itself absorbs in friction so much energy that the loss thus occasioned amounts to a large proportion of the total activity of the machine under examination. The cradle dynamometer is perhaps free from this objection, but it must be rejected on account of the uncertain but large errors introduced by slight errors of centering. Hopkinson's method might be employed, were it not that it requires two machines to experiment upon; an obstacle which in most cases would be a serious one. A method which appears to be devoid of the objections just enumerated is a modified calorimetric method. To employ this the motor or dynamo, as the case may be, is surrounded by an air-tight water jacket through which circulates a stream of water at a uniform temperature. The dynamo is allowed to run under a given load until all the effects of heating have become constant; this includes the heating resulting from mechanical friction, and from the current itself. After this the flow of water is determined, its temperature carefully noted, and from these data the losses occurring in the motor are at once deducible. There appears to be nothing in the way of making the method universally applicable to small machines, and the indications are that its adoption would lead to very accurate results. This method was first proposed by Dr. Duncan as a means of measuring the efficiency of alternating current converters.

Several methods of determining the magnetic qualities of iron and steel have been published. They all depend upon the measurement by a ballistic galvanometer of the induction through a coil wound about the specimen to be tested, either when the coil is moved, the current reversed, or reduced to zero. These methods offer no difficulty, and a ballistic galvanometer can easily be calibrated in absolute measure by the use of an earth inductor or even a coil of wire of a few turns, its constants having been determined by measurement and simple calculation.

Dr. Moses—Would Dr. Liebig be so kind as to explain to us how in the measurement of small machines the difficulties developed themselves?

Dr. Liebig—The difficulty we had was that the dynamometer used required so much power to move. The dynamometer that is best fitted for that work is perhaps the Taten dynamometer; but it cannot be very well made on a very small scale, and it absorbs something like half to three-quarters of a horse-power to run it; so if you want to measure the efficiency of a one horse motor you have very little to go on.

Dr. Moses—Has Dr. Liebig determined the relative losses of direct and alternating motors?

Dr. Liebig—I have not as yet taken up that subject.

REPORT ON PATENT LEGISLATION.

Mr. Arthur Steuart, chairman, committee on patent legislation, then reported as follows:—Do not be frightened by this volume

of matter that I have here. I am not going to read it all. I only brought it for distribution. Six months ago, at the Pittsburgh convention, the committee on patent legislation was instructed to prepare two bills for introduction into Congress, one of them for the creation and organization of a Court of Patent Appeals to hear appeals in all patent cases coming from the circuits and from the patent office, for the purpose of shortening the final determination of causes and sending them to the Supreme Court directly, and also for the purpose of putting over the two branches of the government that has to do with patents, namely the Circuit Courts and the Patent Office, the same tribunals, thereby giving a harmonizing influence and creating a degree of harmony between them that does not now exist. We are all conscious of the confusions and we are all conscious of the difficulties, and it was determined that this was the best method by which harmony in the law and practice could be accomplished. For the purpose of formulating a bill that would be satisfactory, for the creation of such a court, your committee proceeded to correspond with every member of the association and everybody in this country who was found interested or from whom they thought they could get information, and I can say to you that the volume of that correspondence has been very great. As a result of the three months' work, the bill which I have in my hand and which I will not read in detail but simply call your attention to was finally determined upon and it has been submitted for consideration to the Supreme Court of the United States—that august body for which as a lawyer probably I feel greater respect and veneration than you do as laymen ; but it is certainly the most august and dignified tribunal in the world, and one for which we cannot have too much regard. I may say that I feel somewhat gratified when I can report to you that this bill which has been submitted to Congress is the first one within the recollection of any one with whom I have spoken which has received the public endorsement of that great and dignified court. There is printed in this pamphlet, and I will read it to you, a letter from the present acting chief-justice of that court, endorsing the measures. The Hon. Samuel F. Miller, the actual chief-justice at the time this letter was written, says :—

My Dear Sir :—It gives me pleasure to say that, after going over the Bill of the H. of R. No. 9,084, to establish a Court of Patent Appeals, and making a few suggestions which you accepted, I approve of the bill entirely. It will do much to relieve the over-burdened docket of our Supreme Court in a direction where it can best be done.

Although the Bill has been submitted to no distinct vote of the members of the Court, it has been considered by them all, and I feel sure that I express their concurrent opinion when I say that they all desire the passage of the Bill, and will be much gratified if it shall become a law.

I am very truly yours,
SAMUEL F. MILLER.

There is also a letter here from Mr. Justice Bradley, and one of endorsement from the late honored chief-justice.

The following letter from the Hon. Commissioner of Patents is printed in this pamphlet :—

Dear Sir :—I have considered the Bill, H. of R. No. 9,084, with amendments suggested before sub-committee of judiciary committee of the House, and am convinced that it meets the urgent requirements of the present situation. It will tend directly and immediately to relieve the Supreme Court of its enormously overgrown docket, and to abolish the delays in the administration of law which now almost amount to a denial of justice. The patent laws in their application must be applied by expert tribunals. The patent office is an expert in the arts. It is required to be such, not only by the nature of its duties, but by the principles of its organization. It is impossible that judicial tribunals can properly and safely revise and review its work, and adjudge the rights of the public and of individuals arising from its operations, without possessing an element of the knowledge and familiarity of the expert that lies at the foundation of the whole system.

I sincerely trust Congress can be induced to give the subject the consideration it is worthy of.

Yours very truly,
BENTON J. HALL,
Commissioner of Patents.

The matter was submitted for consideration to the bar. In Washington there is an organization which is formed for the purpose of fostering this measure, the Patent Bar Association. The president of that association, speaking for that organization and for the great mass of lawyers in that and other cities, says :—

"The Patent Bar Association of the District of Columbia is strongly in favor of a Court of Patent Appeals, such as is proposed by Bill H. of R. 9,084. We are clearly of the opinion that such a court would be of vast importance.

"First. By securing a far more uniform practice in the granting of patents, by which there would be less invalid patents granted, and the capital invested in patents and business enterprises based upon patents would be rendered more secure.

"Second. It would lessen litigation, and, what is equally, if not more important, it would enable patent cases to be decided in much less time.

"Third : It would relieve the Supreme Court, for very few cases would ever go beyond the proposed court.

"Fourth. It would put an end to the conflicting decisions which is one of the great troubles of the day."

W. C. DODGE,
President Patent Bar Association.

The bill contemplates the creation of a court of five judges, who shall hold their court in the City of Washington, and shall sit as long as is necessary for the completion of the work required of them. That court shall have special jurisdiction in all cases involving patents, trade marks and copyrights, for they are kindred subjects and should go to the same courts, on appeal from the Circuit Court of the United States, and also of cases involving the same questions on appeal from the commissioner of patents. The bill provides, on the suggestion of members of the Supreme Court, that this court shall make a finding of fact in all cases, that they shall take all the testimony in the case, and formulate from it a statement of facts which shall be the basis of all appeals to the Supreme Court of the United States. Now, we all know that the questions in controversy in a patent case are as a rule questions of fact. In nine cases out of ten a decision of the facts decides the case, and when this court makes a finding of fact there will not be one case in ten that will leave a bald question of law open to be determined by the Supreme Court. This will probably operate to constitute this court in the majority of cases a court of last resort in patent cases, and we may hope that after trying a case in the Circuit Court, or trying it before the commissioner of patents, we may in six months get a final determination of the case in such a court as this instead of waiting, as is the present rule, three or four years for the determination of a matter in the Supreme Court, with that much loss in the use of the patent.

This bill was introduced into Congress in April—the second of April—and was immediately referred to the judiciary committee of the House. It was referred to the patent committee of the Senate. The judiciary committee of the House has been the field of our labor since that time, and I fear that the members of that committee have begun to think that I have gone mad on this subject ; but any of you who have had experience with the procurement of legislation from Congress have found that the most persistent, constant, untiring effort is necessary in order to get an action from any of the committees. Mr. Hall, the commissioner of patents, Mr. Dodge, the president of the Patent Bar Association, the Hon. George Ticknor Curtis, whom I interested in the measure, other gentlemen from elsewhere, and myself, have been before that committee over and over and over again. We have been there twenty times if we have been there once. We have argued with them hour by hour, and I have here in my hands a batch of articles upon this subject, which have been prepared by very intimate men in various parts of the country—by Mr. Walker, of Hartford, Mr Mason, of Detroit, Mr. Dodge, of Washington, Mr. Curtis, of New York, all of them tending to demonstrate the necessity for the creation of such a court, and for the purpose of proving to the members of Congress the desirability of passing this measure. The day before I came away from home, I had the gratification of receiving a telegram from the chairman of the judiciary committee of the House, to say that after careful consideration, that committee had authorized him to report this committee to the House, with a recommendation for its immediate passage. (Applause.) I cannot say what the House will do with it, but I have heard few dissenting voices, and I am disposed to hope that, if the members of this association will aid me by individually approaching their members of Congress and indicating to them that it is very desirable that this bill shall pass, that it will become a law ; and I hope that when you go home, that every one of you will take the very first opportunity of either writing or going to Washington, seeing your members of Congress, and impressing upon them your personal desire that this thing shall go through. I may say that the House committee have cut down the court from 5 to 3 members, and have cut down the salary from $8,000 to $6,000. I am sorry for that. The burden cast upon this court by the transfer to it of cases now on the docket of the Supreme Court will be very heavy, and the mass of business thrown upon them will be very great. I do not think that three men can do the work. The Senate committee that has the matter in charge have assured me that when the bill comes to them, they will alter that, and instead of lowering, will increase the court to seven members and the salary to $9,000, so that we may hope to get good men. It is a question of policy as to whether it would be better for us to let the bill go through in the form in which it has been reported to the House, get the court, try the experiment, and if the justices are overburdened with their work, increase their number afterwards; or whether it would be better not to take our court at all until we can get what we want. My disposition is to let the bill pass through the Senate in the form in which it comes from the House; let the court be appointed, and let them try the work and see how they get along with it.

There is only one other word I will say in this connection. The work of this committee heretofore has cost within a few dollars of $700. When I undertook this work, I estimated the cost at $1,500. I said I thought it could be done within that figure. The members of the association have been very liberal and prompt in supplying the necessary money. Seven hundred odd dollars was subscribed and seven hundred of it has been spent. It remains with the members of the association to say whether this work shall go on or whether it shall stop. It is impossible to prosecute it without sufficient money for the conduct of correspondence, which has made it necessary to employ a clerk, and I may say that for the past six months, the work of this committee has occupied the whole time of one clerk in my office, every bit of it, and he a stenographer, and as much time as I could give to it in addition, the clerk simply, of course, doing the manual work.

It remains for the members of this association to continue this work or to stop it now. We want a little more money in it—a few hundred dollars, and we believe that the benefit of this measure to the members of the association will be so great, that whatever they may spend upon it, they will be well compensated for.

Mr. Foote—As I was one of the few at the last meeting of this association to give our friend Mr. Steuart a little encouragement in his work, I deem it a privilege now to express to him my personal thanks, and I hope the thanks of all the members present, for the work he has done. I think he has got it in excellent shape and that it should be carried forward.

With regard to the question he asks about having the bill passed as it is, without an increase of judges or salary, I think the principle recognized in all legislation is first get your commission, then give them power. On that principle, I would favor any action that would secure the court. Having secured that, if we find it inadequate to its work, it will be easy enough to increase their number, their compensation, and all necessaries to carry on the business.

Mr. Steuart—I failed to say one thing, which I think it right to say, and that is that the money which has been expended on the work of this committee, had been the voluntary contribution of individual members of the association, who have been sufficiently interested to come forward and supply the funds. I do not ask that any of the funds of the association be applied to this purpose. I am satisfied that if the work is continued and if the association feels interested in it and approve of the work as it has been done, that funds will be forthcoming from the individual members to carry it on.

Mr. Weeks—I move that the report of the committee be received and filed, and the committee continued; and in making that motion I want to say that I feel proud of our legal committee. I think they have accomplished a noble work, and I feel quite sure from what I have heard from members of Congress that they are on the way to success.

Mr. Garratt—seconded Mr. Weeks' motion.

Mr. Foote—I would suggest to the mover of that resolution, that he add to it that the treasurer of this association be authorized to open the subscription for a fund to carry on the work.

The President—That had better be made separate from the other motion. It introduces a money matter in connection with the adoption of the report. Before putting the motion for the adoption of the report and continuing the committee, I would like to say a few words. I took the pains to go down to Washington at Mr. Steuart's request to aid him as much as possible in the prosecution of this work before the committee; and no man, unless he has been through that kind of legislation, can appreciate the amount of hard work it takes to see the various members of the committee of a legislature or of Congress, the amount of time spent in hunting them up, the amount of time spent in trying to get a quorum; add to that the amount of labor that Mr. Steuart has performed in conducting all this correspondence, and in collecting data and the opinions of these learned gentlemen, and the endorsement which he has secured from the legal fraternity and the members of the Supreme Court itself—consider all that, and it is certainly something that deserves the thanks of the association. You know we restricted the committee in this way: We said we will give you the moral backing of the association to prosecute this work, but we will give you no money. Now that is a pretty easy thing to do. But, as he says, the individual members of the association have stepped forth and so far paid the expenses. It is gratifying to know that outside of ourselves, as an organization, the members feel such an interest in matters of this kind that they are willing voluntarily to come forward with sufficient funds.

The motion to thank and continue the committee unanimously carried.

Mr. Foote then offered a resolution that the treasurer of this association be authorized to open a subscription for a fund to defray the expenses of the work of this committee.

The resolution was adopted.

The President—Before going any further, gentlemen, I desire to refer to some statistics presented by Dr. Wheeler to our stenographer, in order that they may go upon the records and complete his paper. Some of it is the information asked for yesterday, in regard to the number of dead wires and dead poles, and so on, in the City of New York. (See page 435, for the tables of Dr. Wheeler.)

Mr. E. R. Weeks, of Kansas City, than read the following paper :—

ELECTRICAL EDUCATION.

BY EDWIN RUTHVEN WEEKS.

The signs of the times point to a growing interest in electrical education. In the rapid development of the applications of electricity, the demand for skilled workmen far exceeds the supply, and both employers and employés are beginning to realize that the men at hand must be assisted to a mental culture, whose lack is one of the drawbacks to perfect service.

In response to a few remarks made on this subject at the Boston convention, I have received so many letters of inquiry as to the ways and means of acquiring knowledge which will be of practical value to the workman, that it may be profitable to outline a plan that has proved its working value to employés of all grades of educational advancement, the greater number of whom, however, had previously had so little commerce with books as to be almost helpless before a small library.

When the full measure of the utility of electricity has been reached and when schools have had time to understand the needs of electrical engineering, the work of the college will afford all the preparation that theory can give. Already good courses in this line of investigation have been added to the curricula of many universities. With this branch of the subject we are not at present concerned. But it may be said in passing that the practical work in the factories, which is intended to supplement the college course, is not sufficient to make a man an electrical engineer. So great has been the demand for "expert" service, that many new fledged bachelors of science have been rushed through factories, and sent out to do work requiring *manual dexterity* and an *intimate practical knowledge* of the operation of apparatus under widely varying conditions. Before the student enters the factory he should have taken his degree, and should have spent at least a year at central station work where he may learn to use his hands and may become familiar with many varieties of trouble and gain an experience which will render the factory course of greater value to him. However, our immediate concern is, how to help the army of raw recruits, that the youth and rapid growth of our industry necessitates—to most quickly acquire an intelligent, practical, working knowledge of the service.

The mutual improvement society organized among the employés of the Kansas City Electric Light Co. has learned numerous lessons in regard to proper methods, useful books and the use of them, and in order to open the discussion on this phase of electrical education, I have consented to outline the work of that society. In 1885, the company provided a commodious reading room and a large audience room fitted with a library, paper files, black-boards, tables, writing materials, etc. Some half-dozen electrical papers and magazines are here on file and the library now contains over one hundred volumes. (See list.)

Twenty-five of these volumes, chosen with an eye to simplicity, served as a nucleus to which additions have from time to time been made. The selection of books for first use was an important work, as many texts are gotten up in a style and nomenclature, entirely beyond the taste and reading ability of the ordinary dynamo, lamp, and lineman. The officers of the company made it a point to talk with the men on various subjects treated in the periodicals and books, and to call attention to articles that might be helpful. Other things being equal, those who showed, in their conversation, that they had been studying, were first promoted. The librarian has kept a record of the books taken out, which shows that next to the unabridged dictionary, the one in greatest demand has

been "Electricity in the service of Man," by Dr. Alfred Ritter Von Urbanitzky. Almost every member of the society has read it and some, several times. Next in popularity stand "Elementary Lessons in Electricity and Magnetism," by Thompson, the works of Gordon, Holmes and Du Moncel on "Practical Electric Lighting," and "Electricity; Its Theory, Sources and Applications," by Sprague. Several copies of each of these works had finally to be provided to meet the frequent calls. Men in all branches of the service read them, and find that their perusal results in great benefit. A recent addition to the library, F. M. Kimball's "The Dynamo; How It is Made and How to Use It," whose simplicity and brevity will commend it to every workman, bids fair to become the most popular book with beginners. "Short Lectures to Electrical Artisans," by Fleming; "Elementary Treatise on Electric Batteries," by Niaudet; Hospitalier's "Domestic Electricity;" Brennan's Electricity and Its Discoverers;" Jeans' "Lives of Electricians;" "The Electric Motor and Its Applications," by Martin and Wetzler; "Electrical Measurement and the Galvanometer, by Lockwood; Day's "Electric Light Arithmetic;" "Dynamo Electric Machines," by Thompson; and Pray's "Twenty Years with the Indicator," are also favorite works.

The more purely theoretical treatises are taken out by few; but the number of their readers is gradually increasing. Among the more recent publications, there is one book deserving special mention. It is Mr. Hering's "Principles of Dynamo Electric Machines," which for the clearness, accuracy, and subject-matter should be in the hands of electrical readers of all classes.

The success of the reading room soon led to the organization of the Gramme Society, and the work of its members shows that the men are learning how to read. There was, at first, a little opposition to it among the men, some of whom objected to giving away the information which they had gained by hard knocks against experience. But this feeling has gradually died out, and all have come to realize that, in words of one of our linemen, "This is a case where one can give away his cake and eat it too." An additional inducement to membership was offered by establishing a relief fund in the society, to which each member subscribes at least twenty-five cents a month, the aggregate monthly subscription being doubled by the company. In case of sickness or disability of any member, he receives his *pro rata* share of the fund, and more should the society so decree. So that now, although the membership is not compulsory, most of the men in the service of the company have joined.

The meetings were formerly held on Sunday afternoon, but Tuesday evening was finally selected as a better time. The organization is of the simplest, and there is no membership fee. The officers are elected annually; and a committee, appointed by the chair, chooses the subjects and leaders of discussion under the advice of the general manager, who endeavors to so direct the whole work, that a reading of current electrical literature shall be necessary to the intelligent hearing of the various talks. Care is taken to assign each topic to those who have had the most practical experience in regard to it. Among the subjects already considered are, "A Talk on Magnets," "Early History and Sources of Electricity," "The New Light," "Technical Terms," "Electrical Units," "Ohm's Law," "Shunts," "The Arc Lamp," "The Incandescent Lamp," "Carbons," "Construction and Maintenance of Lines," "Danger from Shocks," "Grounds, Crosses, and Short Circuits," "Lubrication and the Proper Care of Journals," "Various Types of Dynamo Electric Machines," "The Edison and Thomson-Houston Machines; Their Construction and Proper Care," and "The Alternating-Current System." The discussions of some of these subjects required several meetings. In addition to the working topics, a biographical sketch of some noted scientist, especially an electrician, is given and is found to awaken a deeper interest in electrical study. The discussion of the subjects is both theoretical and practical, and the speakers have been led to a free use of the black-board for synopsis, diagrams, and illustrations.

The beginnings of the work were rather disheartening, and it required a great deal of enthusiasm and patience on the part of its inaugurators, to induce the men to take any useful part in the exercises. It was only by continual questionings and references to books and periodicals, by pointing out the advantage to be derived from the perusal of this or that article in this or that paper or book, the constant recognition of the good work of each speaker and the ignoring of the weak and useless, that the men were gradually encouraged to take hold of the subjects in a free and easy way, and to give up the cream of their experience without fear of losing it.

But the results have amply repaid all efforts; and the growing interest of the members, their anxiety for perfect equipment and above all their ready expression of the advantage which the necessary reading and the interchange of thought have been to them, are most gratifying proofs of the wisdom of the movement.

Those members of the society whose information lay chiefly in a practical direction, have added to that information and have gained a knowledge of some of the principles underlying our industry. They are thus deriving more pleasure from their work and are on the way to a higher and wider field of usefulness. Those whose information was mostly of a theoretical nature have clinched such information, and have acquired a more intimate knowledge of the apparatus used, and are thus better prepared to discharge the duties devolving upon them.

The benefits of this work to the company are evident in the improved condition of all parts of the service, and in the interest which the employés take in perfecting it—an interest which has grown out of the dawning perception that the company has at heart the good of its workmen, as well as the increase of its dividends.

LIST OF BOOKS IN THE LIBRARY OF THE GRAMME SOCIETY.

Alglave & Boulard.—The Electric Light; History, Production, etc.
American Electrical Directory.
Anderson.—Lightning Conductors.
Atkinson.—Static Electricity.
Ayrton.—Practical Electricity.
Benjamin.—Age of Electricity.
Blakesley.—Alternating Currents.
Bottone.—The Dynamo; How Made and How Used.
Braunt & Wahl.—Techno-Chemical Receipt Book.
Brennan.—Electricity and Its Discoverers.
Browne.—Fuel and Water.
Buel.—Safety Valves.
Colburn.—Steam Boiler Explosions.
Cooke.—The New Chemistry.
Cotterill.—Applied Mechanics.
Cumming.—Introduction to the Theory of Electricity.
Day.—Electrical and Magnetic Measurements.
Day.—Electric Light Arithmetic.
Deschanel.—Natural Philosophy.
Du Moncel.—Electric Lighting.
Du Moncel.—Electricity as a Motive Power.
Du Moncel.—Incandescent Electric Lights.
Du Moncel.—Electro-Magnets.
Dyer.—Induction Coils.
Everett.—Elementary Treatise on Natural Philosophy.
Faraday.—Experimental Researches in Electricity.
Fiske.—Electricity and Electrical Engineering.
Fleming.—Short Lectures to Electrical Artisans.
Gordon.—Physical Treatise on Electricity and Magnetism.
Gordon.—Practical Treatise on Electric Lighting.
Gordon.—School Electricity.
Haskins.—The Galvanometer.
Hering.—Principles of Dynamo-Electric Machines.
Holmes.—Practical Electric Lighting.
Hopkinson.—Dynamic Electricity.
Hospitalier.—Domestic Electricity.
Hospitalier.—Modern Applications of Electricity.
Jeans.—Lives of Electricians.
Jenkin.—Electricity and Magnetism.
Kapp.—Electric Transmission of Energy.
Kempe.—Hand-Book of Electrical Testing.
Kimball.—The Dynamo; How It is Made and How to Use It.

Lockwood.—Electrical Measurement and the Galvanometer.
Lockwood.—Electricity, Magnetism and the Electric Telegraph.
Lomnell.—Nature of Light.
Maier.—Arc and Glow Lamps.
Martin and Wetzler.—The Electric Motor.
Maxwell.—Electricity and Magnetism.
Monroe and Jamieson.—Pocket Book of Electrical Rules, and Tables.
Niaudet.—Elementary Treatise on Electric Batteries.
Nead.—Student's Text Book of Electricity.
Planté.—Storage of Electrical Energy.
Pray.—Twenty Years with the Indicator.
Prescott.—Bell's Electric Speaking Telephone.
Prescott.—Electricity and the Electric Telegraph.
Proceedings.—The Association of Edison Illuminating Companies.
Proceedings.—The National Electric Light Association.
Pynchon.—Chemical Physics.
Radau.—Wonders of Acoustics.
Rowan.—Boiler Incrustation and Corrosion.
Sawyer.—Electric Lighting by Incandescence.
Schilling.—The Present Condition of Electric Lighting.
Smith.—Work Measuring Machines.
Sprague.—Electricity: Theory, Sources and Applications.
Stewart.—The Conservation of Energy.
Swinburne.—Practical Electrical Units.
Thompson.—Dynamo-Electric Machines.
Thompson.—Dynamo-Electric Machinery.
Thompson.—Elementary Lessons in Electricity and Magnetism.
Transactions.—American Institute of Electrical Engineers.
Treglohan.—Magnetism.
Treglohan.—Static Electricity.
Tyndall.—Lessons in Electricity.
Urbanitzky.—Electricity in the Service of Man.
Watt.—Electro-Deposition of Gold, Silver, etc.
Webster.—Unabridged Dictionary.
Wentworth.—Practical Arithmetic.
Wentworth.—Complete Algebra.
Wentworth.—Plane and Solid Geometry.
Wheeler.—Trigonometry.
Wigan.—Electrician's Pocket Book.

DISCUSSION.

The President—You have before you for discussion this very able and practical paper of Mr. Weeks, describing a school for imparting practical knowledge, under the management of his company, guiding its men in such channels as to give them the most practical and useful knowledge.

Dr. Moses—I think Mr. Weeks has set a very good example to all companies. There is no relaxation to the hard working man equivalent to studying up why he works and how to ease his work. It is very necessary that the people who are employed in the lower positions should be better educated. They are apt to get into a perfunctory way of doing their duty. Many an important thing too is suggested by the man who is engaged in running the apparatus.

In an humble way I have been at work on something in the same province. I take pleasure in announcing to you that I am now trying to breed up for you a class of workmen who will take charge of many of the positions in the electric stations and who will be able to do a great deal of work for you and do it intelligently. Next year I hope to be able to tell you of some practical results from it. There is a school in this city with which I happen to be connected as director and vice-president, which has for four years been engaged in educating poor boys. We have now about 125 boys under tuition. I have tried to develop in that school a system by which those boys may become useful to us. I look upon the electrical business as the rising business of this country. All other businesses in which motive power is developed will gradually be absorbed by it, and the workmen necessary to be employed in that are very scarce and are becoming scarcer every day. We have been dependent on foreign importation largely for our supply of skilled workmen. They have somewhat banded themselves together, and it is very difficult for a native to get that education which we find many of our foreign workmen have. The object of this school is, as I say, to furnish young skilled apprentices, thoroughly educated in electrical methods and for electrical purposes. I hope next year—though we have some 25 or 30 of our boys at different electrical works doing very good work—I hope to be able to announce to you that the matter has taken such shape that you may look to them for a certain supply of capable employés.

I am very glad to see that Mr. Weeks, who seems to be a born educator himself, has directed his attention to it.

Mr. Foote—Mr. President, I consider this subject of education as the basis of our business. While here I have taken the pains to get every periodical I could find treating on the subject, intending to give them to our workmen.

A point that Mr. Weeks touched upon I have had a little experience in, and that is that some of the workmen do not like to give away what they know, what they have learned practically. About six weeks ago I had occasion to learn something. I addressed a letter of inquiry to the managers of 100 central stations located in every state in the United States. I have received to that letter of inquiry up to to-day 86 answers, and all of the answers have given me in the fullest detail which the writer possessed the ability to give, a full answer to the questions I asked. That experience gives me a good deal of faith to believe that the questions which the committee on insulation have formulated and sent out will produce a great deal of good in bringing in answers. It struck me while Mr. Weeks was reading his paper that possibly it might be well to institute some sort of a circulating library scheme among the local companies in the different localities having, say, a small fee for the use of the books; a fund could be raised by which any book published could be made available to any man who has the intelligence to read it.

Mr. Steuart—I have been deeply interested in this paper of Mr. Weeks, and also in the remarks of Dr. Moses upon this subject, and I would throw out for your consideration one suggestion: The greatest educational influence that has ever been brought to bear upon a community, the greatest influence for practical progress in the development of the arts has been the patent system of the United States. It has done more to make this business than any other one cause, and I would suggest to you, that the spirit of that system is that the government of this country exercises a paternal care over its citizens and extends to them the strength of its arm in protecting them in whatever new step forward they may make in the development of any branch of science or art. The result is, that every citizen of this country feels that what he may do, what he may create as a step forward in the arts becomes his property in the present state of our law, and that he may reap from it the benefit which he certainly deserves. There are some manufacturing organizations in this country that have tried the experiment, and have found it most successful, of constituting themselves a patriarchal government over their employés in the same spirit and under a somewhat similar system as that which exists under our patent law, and I would ask you to consider that suggestion that you put before your men a proposition that they shall exert their very best endeavors to improve the condition of your service, and that for every idea of improvement that they present they shall receive recognition. That recognition I feel satisfied will give you a quality of service that will pay you for its cost.

Mr. Lynch—I must say that I have been highly interested in the remarks of Mr. Weeks, Dr. Moses, and Mr. Steuart, and for the purpose of following up this very interesting topic I will offer the following resolution and suggest the appointment of a committee of three, Mr. Weeks to act as chairman, for the purpose of considering the advisability of communicating with and suggesting to all our scientific colleges that they should follow up a course of practical electric instruction.

The President—The resolution is that a committee of three, of which Mr. Weeks shall be chairman, be appointed to suggest and recommend to all our scientific colleges a course of practical electric lighting education.

Mr. Weeks—While I appreciate the compliment the gentlemen would pay me by constituting me chairman of that committee, I feel that there are so many drains upon my time and strength that I shall not be able to carry that matter on as it should be carried on, and, therefore, I would respectfully withdraw in favor of Dr. Moses.

The resolution was adopted.

The committee on the place of meeting and the nomination of an executive committee then reported as follows:—

"Your committee appointed to select a place for the next annual meeting of the Electric Light Association begs leave to report, that it recommends the City of Chicago for such place of meeting. So far as your committee has been able to learn there is a general sentiment in favor of holding this meeting in some Western city, and other Western cities have consented to waive their claims for the next meeting in favor of Chicago.

"As members of the executive committee for the ensuing year we recommend the following names: Chairman, B. E. Sunny, Chicago; S. A. Barton, Chicago; W. A. Kreidler, Chicago; O. A. Moses, New York; E. F. Peck, Brooklyn; J. F. Morrison, Baltimore; E. T. Lynch, Jr., New York; T. C. Smith, Philadelphia; F. Ridlon, Boston."

C. A. Brown, *Chairman.*
A. J. DeCamp,
H. D. Stanley,
Thos. Officer,
E. R. Weeks.

On motion of Mr. Lynch, the report of the committee was adopted, and a ballot for the election of an executive committee was unanimous for the gentlemen named in the report.

Mr. Steuart, chairman of the committee on the president's address, presented the following report:—

Mr. President and Gentlemen:—"I am instructed by the committee on the president's recommendations, of which I have the honor to be chairman, to make the following report: There is but one subject contained in these recommendations that has not already been disposed of by the convention, and that is the question of establishing a permanent office for the association.

"Ever since the organization of the association a need has been felt for some permanent officer who would be in a position to gather up all the threads of the association's work and bring them to a practical focus, collect and collate information needed by the members and not furnished by the reports of the convention, and have this information ready for the use of the members when needed. It has not heretofore been thought best to undertake this work, but your committee, after careful consideration, agree with the president in thinking that the time has come for the establishment of such an office.

"They also think that the officer proposed should be a person thoroughly familiar with the field of electric lighting and kindred subjects, and that his office should be located in the City of New York, and be furnished with such a collection of books and magazines as would enable him to keep himself abreast of the development of the science and the industry. The committee, therefore, recommend that a resolution be adopted by the convention to the effect that the association have a permanent location in the City of New York, and that the position of secretary and treasurer of the association be held by an expert electrical engineer, and they recommend that the president at once take steps to nominate a suitable person for this position, and select a suitable location in this city for a central office."

ARTHUR STEUART, *Chairman.*
EDWIN F. WEEKS,
A. F. MASON,
HENRY D. STANLEY.

The committee submitted the following resolution :—

"*Resolved*, That this association shall hereafter have a permanent office in the City of New York, which shall be in charge of an expert electrical engineer, who shall be the secretary and treasurer of the association, and that the president at once take steps to procure the services of such a person, and establish him in suitable quarters and with suitable facilities in this city."

Mr. Phelps moved the adoption of the report.

Dr. Moses—It seems to me that we ought to take into consideration the valuable service of the secretary, and before that resolution is offered I would propose a substitute for it, or at least an antecedent resolution, in which Mr. Harding's services shall be properly recognized by the association. If the stenographer will take the resolution down I will dictate it. As we have been faithfully served by Mr. Harding I think he should receive some recognition from us for that in the way of a vote of thanks and appreciation. I therefore move that the appreciative thanks of this association be tendered through the president to Mr. Harding, of Baltimore, for the zealous manner in which he has performed the functions of his office, the care that he has taken to have everything in the way of records properly prepared, and that we congratulate ourselves upon having had a secretary, our first salaried officer, so efficient a one as Mr. Harding.

Mr. Steuart—I am prepared to second that motion in the name of the committee.

The President—Will the chairman of the committee state if the committee has ascertained about what the expense of the proposed office in New York will be, and if the association, in their judgment, is able to meet it.

Mr. Steuart—The committee would only say that during the coming year the income of the association will be somewhere between $4,000 and $5,000. In view of that fact the committee thought that half of that sum might be expended for the purpose of maintaining this office.

The resolution of thanks to Mr. Harding was unanimously adopted by a rising vote.

The motion to receive the report of the committee and adopt the resolution proposed by the committee was carried.

The President—I have here a telegram—a somewhat peculiar telegram :

Cincinnati, O., 31.

President National Electric Light Association :—

"Have association select an expert to act with our committee on award for electrical appliances. Will inform you later when he will be needed."

L. C. GOODALL, *Chairman.*

Gentlemen what is your pleasure?

Mr. Foote—In explanation of that telegram I wish to say to the association that the commissioners of the centennial exhibition in Cincinnati have expended about $40,000 in electric lighting and other electrical display, and there are several private displays. They have some committees to examine this electrical work and make reports upon it. As we have no local talent of commanding influence the commissioners have thought proper to invite this association to nominate an expert to act with their committees so that the action taken or the judgment given would command the respect of the electrical fraternity, and in respect to that telegram, I move you, sir, that the president be authorized to appoint such an expert to co-operate with the commissioners of the exhibition.

Mr. Lynch—While deeply sensible of the compliment conveyed to us by the gentlemen in Cincinnati, I think we are going very much out of our province in sending a delegate there to determine upon the question upon who shall take priority as regards successful apparatus at Cincinnati. It is something we have never done heretofore.

No one seconding Mr. Foote's motion, the matter was dropped.

Mr. DeCamp—I beg to offer the following :—

"*Whereas*, The value of capital is determined by the profits realized thereon, and

"*Whereas*, The risk attending the business of electric lighting, make it preeminently necessary that its capital be surrounded with such safeguards as will protect it against illegitimate competition, and

"*Whereas*, The practice of parent companies of furnishing apparatus and capital for the establishment of plants in cities and towns where local capital has already been invested is a growing evil ; therefore be it

"*Resolved*, That this association denounce such practice as detrimental to a common interest, and recommend its members jointly and individually to suppress it even to the extent of discriminating against all systems which persist in such practice."

Mr. Weeks—I move the adoption of the resolution.

Mr. DeCamp—At the Baltimore meeting a resolution was passed and a committee appointed on this subject. There was a report made that the committee had found little or nothing to do. In the last year or two I have heard very little of the evil, but since I came to this convention one case has been specially named in which there is absolute evidence of all the facts. It simply comes to this : That a parent company will by any means it can, legitimately of course, invite local capital to establish plant, and you know that they only get that capital and establish those plants on representations as to the return of the capital invested. They succeed in doing that. No sooner is that done than they offer, probably indirectly, but nevertheless with the same effect to loan to city authorities and other companies who are ambitious, both material and money to compete for public lighting. What is the result? I hear of public lights being offered as low as 12½ and 15 cents per night. That is downright robbery on the part of parent companies. If they know anything at all they know that there is no apparatus that will produce light for that price, and I do not think any action this convention can take will be too severe on any such party.

Mr. Ridlon—In regard to the committee Mr. DeCamp refers to and the action that was taken at Baltimore, that committee did call on a parent company who thereupon acknowledged their error and promised not to repeat it. It has been repeated now and fully as flagrantly as it was done in the first place, and as Mr. DeCamp says it certainly deserves a censure from this association.

The resolution was adopted.

The President—The chair will appoint as a committee on education, so that there may be no trouble in regard to the chairmanship, Dr. Moses, Mr. Weeks, and Mr. Foote.

Mr. H. L. Lufkin then read the following paper.

A BASIS FROM WHICH TO CALCULATE CHARGES FOR ELECTRIC MOTOR SERVICE.

BY H. L. LUFKIN.

THE theoretical side of the electric motor question has been very ably presented to and discussed by this association, but thus far the practical side has been somewhat neglected.

It will be my purpose in this paper, if possible, to show that there is a general average controlling the use of machinery which it will be safe for electric light and power companies to follow in making their charges for motor service, rather than adopt an arbitrary price per horse-power regardless of the character of service required of the motor.

I have arranged what might be called a power curve, representing the approximate average actual service in electric motors in connection with the several classes of work represented in the list accompanying the diagram.

This curve is calculated on motors which are only of sufficient capacity in each case to carry the full load. If the motor should be larger than is necessary to drive the machinery, the percentage of actual service will, of course, drop below that shown in the diagram.

By adopting a basis of averages which shall be general among members of this association, the charges for a constant horse-power of current may vary with the circumstances of its first cost in each case, but the general classification of motor service may be a comparatively fixed rule. I am not prepared to say that this is the best plan to follow, but respectfully submit the following as a possible solution of the frequently asked question : "How shall we charge for electric motor service?"

EXHAUST FANS.

First on the list of power consumers is the exhaust fan, taking it in average use. There are, however, circumstances under which its use will be limited to as low as 70 or 75% of its contract hours of service. As for instance, in a dining-room it may be cut out except during meal hours, or entirely cut out on cool days. In places of this description, however, its contract use is usually limited to three or four months in the year, and other than electric power is, by circumstances of first cost and inconvenience, but a feeble competitor. The first four applications on the accompanying list, viz.: Exhaust fans, blowers, ceiling fans, and fan outfits are all more or less subject to the foregoing conditions; and, therefore, current supplied to motors for these purposes commands the maximum price per horse-power. One important feature in the installation of ceiling fans is the counter-shafting to the motor. In one recent case we had a complaint from a customer that the ½ h. p. motor sent him would not drive two ceiling fans, and that the motor must be defective, and should be returned for repairs. We immediately sent a representative to find the difficulty, which was found, as is usual in such cases, in the counter-shafting, or rather the want of it. The 3-inch pulley on the motor was connected to a 6-inch pulley on the line shafting. The rated speed of the motor was 2,000 revolutions, and had it been able to develop this speed, would have driven the line shaft 1,000 revolutions and the fans at a relative speed. To accomplish this would probably require a motor of 3 or 4 h. p. The line shafting driving ceiling fans usually runs about 75 revolutions. To give this speed on the line shaft with a rated speed of 2,000 on the 3-inch pulley of the motor would require a counter-shaft, with a 24-inch pulley belted to the motor. On this same counter-shaft should be a 5-inch pulley belted to a 15 or 16-inch pulley on the line shaft. Fully three-fourths of the trouble found in electric motors arises from improper shafting and belting. A ½ h. p. motor should drive the average make of 30-inch exhaust wheel, about 400 revolutions. Say then the speed of the motor is 2,000 and the pulley 3-inch, it would require a 15-inch pulley on the fan to do the work; a 36-inch wheel requires 1 h. p. to develop the same speed. If the motor speed is 1,800, the pulley 4-inch, it would require an 18-inch pulley on the fan to do the work. These are the most popular sizes of exhaust wheels.

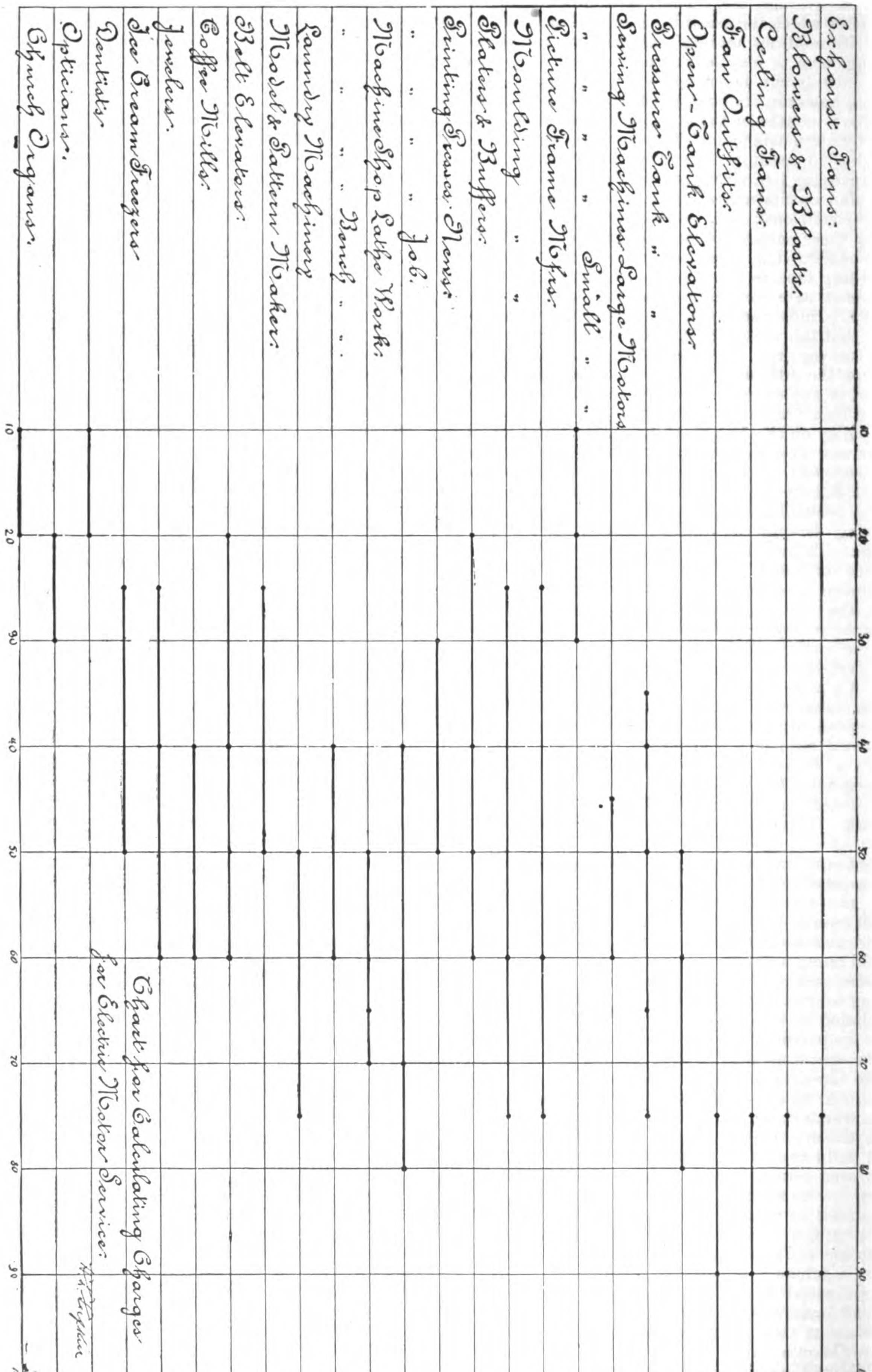
The next application on the list, open tank elevator pumps, commands the highest price for current per horse-power in the motor of any elevator application. The methods of operating the open tank hydraulic elevators in question are undoubtedly familiar to you all. Instead of the usual steam pump a power pump of some approved design is substituted and connected to the motor by suitable counter-shafting to give the required revolutions at the pump. The regulation of the motor in this case should be controlled by the position of water in the lower tank, as in the case of the steam pump. And in this connection let me suggest the necessity of great care both in installation and insulation. On all installations in basements and cellars or elsewhere, where there is the slightest tendency to dampness, raise the motor off the floor on a suitable frame or stand, and build around it on all sides of possible approach a low platform, using glass insulators as legs or standards to support it. So arrange this that the motor or its connections cannot be reached except when standing on this insulated platform, and the liability to a shock will be reduced to the difference of potential between the terminals of the machine. To return to the subject. Let us take for an illustration an elevator using 120 gals. of water per trip, and consuming one minute in making its entire up trip, or about two per round trip. The lower tank or water supply is on a level with the pump. The upper tank is 70 feet above the pump, and in the piping to the upper tank are five elbows. For each elbow add two feet to the elevation, or an approximate total elevation of 80 ft. × 120 gals. gives us 9,600 foot gals. This amount would be required every two minutes if the elevator was in absolutely constant operation, or 4,800 foot gals. per minute × 8½ gives us 40,800 foot pounds. This we must at least double to allow for friction in pump, shafting, etc., making 81,600 foot pounds, or about 2½ say 3 h. p., required in the motor.

This class of elevator is confined almost entirely to passenger use, therefore the service required of the motor is much more constant, and the margin between the horse-power hours contracted for, and the horse-power hours of actual service much smaller than in any other elevator use, excepting possibly the service in connection with pressure tank elevators in the more popular office buildings. In this case we have a maximum average use of 80 per cent., and instances such as the hotels, small office buildings, etc. where the service will not exceed 60 per cent. of the contract horse, power hours. In order, however, that the electric light company shall derive the greatest benefit from this inconstant service, the installation and wiring should be the best, and only the most approved and economical apparatus employed.

The next application on our list, pressure tank pumps in connection with elevators, represents a somewhat smaller percentage of horse-power hours of actual service in the motor, as compared with the possible horse-power hours, than in the case of an open tank pump. In case of the pressure tank the water reserve is usually limited, and the motor therefore must be equal to the continuous operation of the elevator at maximum load. Taking this fact into consideration, and the circumstances of elevator use being about the same in this case as in case of the open tank elevator, we have a greater ratio of difference between the possible or contract horse-power hours in the motor and the horse-power hours of actual service, the maximum average use being about 70 to 75 per cent., and the minimum as low as 35 to 40 per cent., depending of course on the character of building in which the elevator is employed or the character of service. In calculating the size of motor required on an elevator of this description a very convenient fact to remember is, that every pound of pressure per square inch is equivalent to lifting water about 23 feet, or about 230 feet per 100 pounds pressure. By reducing the required pressure to a relative lift in feet, and knowing the amount of water required by the elevator per minute, the motor calculation becomes the same as in case of the open tank elevator, the same allowances being made for friction, etc., as in the first case. The regulation of the motor in this case should be accomplished by the conditions of pressure in the pressure tank, as is the case with a steam pump employed in this service.

The next application of importance on the list is sewing-machines. In the tests I have been able to make on this class of work I have obtained some singular results. One item of importance is the fact that the single thread machines, which are lightest running, consume the most power in operating. Paradoxical as this may seem it is easily explained. As a rule this class of machine is used on light work such as shirts, ladies' underwear, etc., and operated at a higher speed than any other class of machine. At equal speed the volts consumed on a single thread machine, as compared with a shuttle machine, are about as two to three. In average commercial use, however, the positions are reversed, and the ratio of volts consumed in the single thread, as compared with the shuttle machine, is about as five to three. To double the speed on a sewing machine requires about two and a half times the power. The difference in volts consumed on the different makes of sewing machines is so small that we may disregard it entirely, as well as the character of work done by the machine, for the heavier the work the slower the speed, and more frequent and longer stops on the machine, thus keeping the average volts per operator about constant in all cases. This leaves

the speed in stitches per minute at the sewing machine the factor from which we must calculate the power required in



a sewing machine plant. To illustrate this I will give you the record of two cases, which are about the average.

Case No. 1 is a shop in which are 30 sewing machines, connected to a 2 h. p. motor. At the time the tests were made there were but twenty operators at work leaving ten idle machines, the entire shafting, however

being in operation. The class of goods manufactured in this shop is a cheap grade of cotton and wool trousers, rather heavy goods to sew. A voltmeter across the terminals of the motor gave the following readings, with the current at 9 amperes. Minimum, 90 volts; maximum, 148 volts; average, 119; which gives us a minimum average per operator of 4.5 volts, and a maximum average of 7.4 volts, or a general average of 5.9 volts per operator. This motor was driving the shafting for 30 machines, and as the average operators employed the year round will not exceed 75 per cent. of the shop capacity, it will, I think, be entirely fair to estimate the average volts per machine rather than per operator, as the user of the motor has contracted for power sufficient to drive his entire plant. In this case then we have a minimum average of three volts per machine, and a maximum of 4.9 volts, or a general average of say four volts per machine. A 2 h. p. motor of 82 per cent. efficiency, with 9 amperes of current, will require about 200 volts to develop two actual horse-power. Two hundred volts therefore is what the electric light company contracts to deliver, while in reality they deliver only 129 volts, or 60 per cent., or a minimum average of 90 volts, or 45 per cent. of the power contracted for. These machines were making about 1,200 stitches per minute, an average of four volts per 100 stitches.

Case No. 2 is a shop in which there are 32 machines, running at about 1,200 stitches, each being supplied with an individual motor of $\frac{1}{8}$ h. p. capacity, and the class of goods manufactured being men's summer clothing, such as white duck vests, flannel coats, and vests, etc., the duck from which these vests are made being about as hard work on a sewing machine as can be found. In this shop were 24 operators at work. The maximum volts in this case were 116, and the minimum 40, a general average of but 78 volts, or about $2\frac{1}{2}$ volts per machine, with four more operators than in the first case, in which we had an average of 119 volts. This shop has been paying the electric light company $32 per month for more than a year, which is the price the same company charge for current for a 4 h. p. motor, approximately 400 volts, which the company contracts to deliver. This gives us a minimum average use of but 10 per cent., and a maximum of 29 per cent, with a general average of $19\frac{1}{2}$ per cent. In other words the company is saving in this shop the price of a $\frac{1}{8}$ h. p. motor each month, besides making a profit on the volts actually delivered. On a contract for three years the electric light company would be money in pocket if they would present the customer with 30 small motors, charging him $1 per month per motor for current rather than let him buy a 2 h. p. motor to operate the same machines with the necessary shafting at a charge of $18 per month for current. Taking this average, in case No. 2, of $2\frac{1}{2}$ volts per machine, from a 50-light machine we could run not less than 900 sewing machines, or about 18 to the arc lamp. At $1 per month per machine an income of $900 per month would be derived from a 50-light machine without any lamp expenses such as carbons, repairs on lamps, globes, etc. On the average, in case No. 1, of 4 volts per machine, we could operate but about 562, say 600 machines. Divided up in shops of 30 machines, and a 2 h. p. motor to each shop, we would have 20 2 h. p. motors. At a charge of $18 per month each we would have an earning capacity of but $360 per month from the same 50-light machine.

This is but one page from the thus far unwritten history of the much maligned small motor. Still the question is frequently asked, "Can we sell current for $1 per month for a small motor driving a sewing machine and make a profit?" As a matter of fact 50c. per month for small motors driving sewing machines yields a better profit to the company supplying the current than $10 per month per horse-power in large motors to drive the same machines; besides the immense advantage which the small motors possess of keeping the circuit in much better balance, the fluctuations due to the stopping and starting of large motors being at times a serious matter. One electric light company making rather a specialty of these small machines, rent the motor and supply the current for $1.25 per month per sewing machine, and report that at this price the motor service pays them a better percentage of profit than their lamps. This company have some 200 small motors on their circuits.

A more striking illustration of the advantages to the electric light company in the sub-division of power into the smallest possible units it would be hard to find. There is a difference in efficiency of from 15 to 20 per cent. in these two sizes of motors, but this difference is fully lost to the large motor in driving the shafting, and the small motor still has the advantage of being out of circuit entirely when the machine it is driving is stopped. There is scarcely a manufacturing industry which does not possess its busy and dull seasons. This means that in no industry will over 75 per cent. of the machines or machinery employed be in average operation. The shafting in these shops must be kept in operation the entire year, often for less than 50 per cent. of the machinery. Sub-divide these same shops into as many small units as possible, and the current necessary to operate the shafting for this idle machinery will be saved, besides the saving from frequent stops while the machinery is in active use.

To return again to the list, the next two applications, picture frame manufacturers and moulding manufacturers, are very similar. Their busy seasons, as a rule, are in the spring and fall, and also follow closely any activity in house building. In the case of the larger manufacturers in this line a maximum average of 75 per cent. will possibly be reached but probably never exceeded. In the case, however, of the picture dealer who has a small shop, in which he makes picture frames and mouldings to order, the actual service of the motor will fall as low as 25 or 30 per cent. of its contract hours, one case in our experience the actual service having reached this low average. A fair general average in this class of work would be about 60 per cent.

The next application, nickel and silver platers and buffers, are good contract customers as a rule. One case in our experience showing but an average use of 20 per cent. of the contract horse-power hours. This, however, is probably an exceptional case, and as near as we can estimate on this class of work, the actual motor service will not exceed, in any case, 60 per cent. of the contract hours. A fair average being probably 45 or 50 per cent.

The next two applications, printing presses on news and job work, are probably met with more frequently than any other. On exclusively news work the instances where the motor is in service more than three or four hours is rare. It is, however, usual in news offices to find two or more job presses. If the newspaper printed happens to be a morning paper, the hours of news work are usually between twelve midnight and four o'clock in the morning, the job work being done through the day. I have in mind a case of this description. In the shop is one cylinder press and three job presses connected to a 2 h. p. motor. This motor is on an incandescent circuit of 110 volts. To develop its rated power at 110 volts would require about 16 amperes in the motor. An ampere meter in series with the motor, while running off the morning paper, with only the cylinder press in operation, stood at 12 amperes. For three hours this load was practically constant, when it was thrown off entirely. This gave on the night service but 30 per cent. of the contract hours. This motor required 5 amperes to drive the shafting, and but 8 amperes or 1 h. p. to drive the three job presses with the cylinder press off. Here then is but a 50 per cent. use if the presses be used constantly; there are, however, many days when they are comparatively idle; 30 to 40 per cent. therefore is a very safe estimate of the maximum use of this motor on the day circuit, or had the motor been a 1 h. p., which

would have been sufficient to drive the job presses, the use would be 60 to 80 per cent. of the contract hours, probably not above 60 per cent. All printing offices will probably come within this range unless the motor be larger than is necessary to do the work.

Machine shops, doing principally lathe work, as a matter of course use a larger percentage of their contracted power than shops doing lathe and bench work with the same hands. In no case will the service of the motor exceed 65 or 70 per cent. of its contract use; for machine shops, like sewing machine shops, will never average over 75 per cent. of the shop capacity for operators the year round. The average, especially in the case of a shop doing much bench work, will fall as low as 40 per cent.

The driving of laundry machinery, which is our next application, usually proves a profitable contract, according to reports. This fact arises from the intermittent use of the machinery. The heaviest service on the motor will probably be found during the early part of each week, with a general falling off in work during the summer months, while the patrons of the laundry are away at the seashore or in the mountains. In this application, therefore, a 75 per cent. service would probably be an exception, with probably many instances where the service would fall below 50 per cent.

The next application, model and pattern makers, are small users of power, as their occupation requires a large proportion of hand work. Fifty per cent. service in the motor will be found a fair average maximum use, with instances as low as 20 or 25 per cent.

The next application, direct power or belt elevators, is another application frequently met. The average service in the motor is also much smaller than in any other elevator application. Let us suppose a case of the familiar grip connected to the ordinary hand-hoist, with a lifting capacity of 2,000 pounds. In this case the motor is in use only going up, and the usual break is used in coming down. Connected to this elevator, in the loft of the building, we have a 5 h. p. motor wired to a cut-out on the ground floor. We will call the lift 45 feet and the time consumed per trip one minute. We will allow 60 full trips of the elevator, at full load of 2,000 pounds per trip each day. This would approximate 10 car loads of merchandise handled by the elevator, which is certainly above the average. This motor, we will say, is on a ten hour day circuit, its possible horse-power hours, therefore, would be 5 h. p. for ten hours, or 50 h. p. hours per day. Sixty trips of one minute each gives us exactly one hour's service of the full 5 h. p. or 5 h. p. hours. To drive the shafting only while the elevator is coming down or idle, would require about 150 volts or 1½ h. p., and if this was in constant operation the balance of the day, nine hours, its total use on shafting would be 13½ h. p. hours, which, added to the 5 h. p. hours gives us a grand total of 18½ h. p. hours, or 37 per cent. of the contract hours. If, however, the user of the motor avails himself of the cut-out box, and cuts the current out when the motor is not in use, the average use would drop to 20 or 25 per cent. instead of 37 per cent. In the case of a direct power passenger elevator the use might possibly run up to 60 per cent., but this would be exceptional.

Coffee mills will average from 40 to 60 per cent. of their contract hours. Manufacturing jewelers about the same, while retail jewelers will run as low as 25 per cent. Ice cream freezers will not average over 25 per cent., but as the contract season in this case is usually short they should be rated at least on a 50 per cent. basis, except possibly in cases where the customer pays the cost of installation and wiring, which is usual in these cases.

A dentist is one of the smallest of power users, so small in fact, that if every one in a city were connected with a circuit, the load from this cause would never be felt. We will, however, put them down at from 10 to 20 per cent.

The optician uses a motor to turn his grind stones, and its use in this case will average from 20 to 30 per cent.

The last application on the list, church organs, use only from 10 to 20 per cent. of the contract service.

These are, of course, but few of the very many applications of the electric motor; and if, as I trust, the possible subsequent discussion of this general plan may establish a basis for rating motor applications, not only will the objects of this paper be obtained but a question of considerable annoyance now existing between the motor man and the electric light or power company will be solved.

In conclusion, Mr. Chairman, I beg to suggest that the supply and rates of charge for electric power have become of sufficient importance to this association to be represented by a permanent committee, whose duty it should be to obtain from the different members of this association, as far as possible, their experience in the supply of power, in such manner and form as shall be deemed by the committee best suited to the wants of this association.

DISCUSSION.

Mr. Colvin, Baltimore—The paper that has just been read should appeal and does appeal to all electric lighting people who have or contemplate having power service with the irresistible eloquence of dollars and cents. The first thing to consider is whether they will use power; yes. Can they make it pay? Well, it is according to what they will charge for power. If they charge too much every gas engine will get ahead of the electric motor. If they charge too little the power business will not pay. If they adopt a cast iron rule and charge so much a mouth for everything they do an injustice to intermittent power, and if they make a sliding scale, the next city will have a different sliding scale, the customers will get together and the consequence will be dissatisfaction all around; so the paper presented brings up one recommendation of a solution to that problem of classification. I think everyone realizes how important that is. As far as the suggestion of small motors is concerned and their advantage over large ones, the writer says this is but one phase of the much maligned small motor. It is very true. The other phase is that companies starting power usually have an idea that the fan business is the great end of all motor service, and they commence with small power. When they put in larger powers they find the larger motors require less inspection than the small ones. The brushes of the small motors require more frequent adjustment. The small motors in the case of sewing machines have to be opposite the machines and exposed, whereas the large motors can be put in a safe place; and in a city where electrical power has long been in use, you will find, if they have used large power, that they will prefer having a 6, 8 or 10 power motor than a number of small motors.

Take the case where Mr. Lufkin figured out that the company could afford to present the manufacturer with 30 motors. He could, if the 30 motors would run without any trouble. But my experience with both kinds of motors has been that I might get in trouble in that way and have some of these small motors give out—even one or two of them, and I might have the 30 motors back on my hands. In the case of small motors again, there are more sliding contacts of the brush and the commutator, more binding posts shaken loose, more broken adjustments, more money for repairs per horse-power—infinitely more money. As I said before the large motor can be placed, if it is an arc motor with a high tension current, it can be placed away from the operating room entirely where it can only be reached by the inspector. As far as the economy is concerned if the motor is so constructed that the amount of current it consumes shall be a function of the work that it does,—of course you will have shafting against the large motor,—but you will have the satisfaction against the small motor. I do not mean to say that small motors are not successful, but I mean that the average general experience is that there has been more trouble with small motors than large ones, and large motors, as a rule, if they are properly constructed, govern better, require less attention and give better satisfaction. I think everyone appreciates the necessity of having some definite classification of this sort. In visiting a city and talking power with people it is almost impossible to get on any scale. I know of a place in the south I visited recently, where the customer told me he was getting electric power very cheap. I inquired what he was paying; he said he was getting it for $20 a month. It was a ½ h. p. His water power used to cost him more. In other places they will growl at $4 a month.

Mr. H. McL. Harding, New York—There are very many valuable points in the paper which was read, and I hope that the managers and presidents of all the electric light companies will read it over very carefully. It shows a good deal of thought. That is the true way to charge for power—to classify the work. By doing that and carrying it out, even a little farther than it is

done there, each electric station manager will then know just what he should charge, and the moment he feels confident, when he signs his name to a year's contract, that he is going to make money, there will be no trouble in placing motors.

In regard to small motors being more economical than large ones, it may be I do not get the figures exactly right; but taking them as he gave them, with his large motor he was running 14 sewing machines to the horse-power. Now you could easily run with 1 h. p. 20 sewing machines, and even above that. He compares a motor which is only driving 14 sewing machines, with his small motor. Probably he lost very much power in his counter-shafting. That is what I should judge.

Now there is one other point of the business which you all find, I think, of a good deal of interest and value, and it is a new branch that has come up almost since the last meeting—come up on any extended scale; that is central stations supplying power to run electric railways. Now the central stations in each case could do that. You could make up your mind that if a street railway company put up a large central station to run their cars they are going to supply light and power. You may say their charter will not permit that. Probably not; but at the same time the same men may form among themselves a second company. In order to prevent that, it is necessary for you to furnish power to run their railways at a reasonable rate. You must remember that a street car will be operated fully 16 hours a day. In the City of Richmond, they are taking about 5 to 6 h. p. per car. That is an exceptionally difficult road to operate, having grades as high as $10\frac{1}{10}$th per cent., curves 27 feet radius, and other details which make it very difficult. You can therefore take it as a certainty that it will not require on an average for your 16 hours a day over 5 h. p., and from that you can calculate what you should charge. A few data referring to that may be of advantage. In Wilmington they are running now three cars, to be increased to 10. They charge $2.50 per day per car. In Carbondale, where they only pay 10 cents a ton for their fuel, using the screenings, they will run any number of cars, up to six, for $7 a day. In Brockton, Mass., the price is about $1.75 per car, per day. In Richmond, the cost there is a sort of a compound arrangement, because they are supplying light as well as power from the same station, and they estimate that they will charge the railroad company $1.66 per day per car. In a neighborhood where coal costs $3 or $4 a ton and the cars run 16 hours the charge would be somewhere between $1.75 and $2.50 per day.

I present these facts because I think the question will come up before long to most of you in regard to supplying power for the railways in local places. In some of the large cities where the service will be through an underground conduit the electric companies are considering that they will supply 7, 8 or 10 h. p. to operate the road, and they are willing to make such a rate that the railway can afford to take their power from them rather than put up their own station. Of course in that case the margin of profit would not be as large as in the other case.

Mr. Ridlon—I have had but very little experience in the matter of selling power, and have been but comparatively a short time in the motor business. I fail to understand the gentleman's theory thoroughly in regard to small motors being economical. In all other branches of machinery we have always found that where the power was even, a large engine would operate more economically than the small one. I have found it in motors the same. In the first place it takes but one set of wires. You can connect it up with the outside lines as cheaply for a 10 h. p. motor as for a ½ h. p. motor. The inspection for a 10 h. p. motor costs no more than for a ½ h. p. motor. I have found by actual experience that a man who was using a 15 h. p. engine and thought that he wanted 15 h. p. to drive his machinery was not only perfectly satisfied with the power he got from a 10 h. p. motor, but thought he had some to spare and that he could do even with less.

The question that has come up here in regard to the regulation of price for power, that is, charging for what average power is required, seems to me a very important one; that is a question on which hinges a very large portion of the future motor business—getting down to the fact of the amount of power which the customer is using, and the sooner that we can get any actual data in regard to these facts before our association and before our electric light companies, the sooner we can increase the volume of our motor business; and I was in hopes this discussion that we would hear not especially from the motor men, but from the people also who are furnishing the current to the parties using the motors, and I hope this discussion will not close until we have heard from some of the superintendents or managers of the central stations throughout the different parts of the country.

Mr. G. A. Redman, Rochester, N. Y.—We rent 296 motors. We receive $18 for ⅛, $48 for ½ h. p.; $72 for 1 h. p.; $225 for 4 h. p.; $300 for 6 h. p.; $325 for 8 h. p. Of course, you understand, we run all by water and do not use any coal. I would state I have a ⅛ h. p. motor running an elevator, and we find that the average time is not more than twenty per cent.

Mr. Ridlon—I would state in regard to the question of water power, that, of course, that matter would hardly be understood by the steam power people. I am now making arrangements in Maine where the parties will make a very handsome profit, and one that will bring a smile to the faces of most of the members here, should I state it.

The President—It would be a good idea to have those figures. There has not been much smiling this morning.

Mr. Ridlon—They figure their horse-power at $25 a day. I would state the fact that a horse-power costs them $2.50 per year, and they have got 4,000 or 5,000 h. p.

Mr. Lufkin—I would like to say in reply to Mr. Colvin that I think he rather exaggerates the repairing expense of small motors. In the case of one shop, which I referred to, where they had 32 small motors in operation, I took pains the other day to look up the repairs in the shop for the past year, and in that place there have been but two commutators turned out, out of 32 machines, and there has been no armature that has given out. There has been no accident in the shop of any kind from any cause, and the service is reported by the people using the machine as very satisfactory. I do not mean to argue that a ⅛ of a h. p. motor is the only motor that can be used, by any means; but the profits of the electric lighting company arises largely in subdividing their power—in suiting the motor to the work in each case.

Mr. Colvin—I would like to ask if those were run on incandescent lines or arc lines?

Mr. Lufkin—That was on a Brush arc circuit.

Mr. Colvin—Were they run all the time during the year?

Mr. Lufkin—Right through the year.

Mr. Colvin—Did they carry the full $9\frac{6}{10}$ current?

Mr. Lufkin—I understand so. The current in this case is a trifle under $9\frac{6}{10}$; I should say it is about 9 amperes.

Mr. Colvin—The reason I ask that question is that many motors with which I am familiar, owe their length of life to the fact, that although they run $9\frac{6}{10}$ in the night, they run 8 and 8½ all day.

Mr. Colvin—My remarks about small motors were simply from experience of fifteen or twenty cities, where different types of motors were used. I know one or two motors of a very small size that have run better than large ones; yet it seems to me, they were exceptional. What I stated was simply my average experience, and from what these electric light companies told me, and also from their anxiety to get larger size motors and larger generators on the market.

Mr. Lufkin—I think that is rather from a lack of the appreciation of the merits of the case. I think that as soon as the question was thoroughly understood by the electric lighting people, they will take in these small motors, and they will be more ready to adopt a scale, such as I have suggested there, for selling their power.

Mr. Law—We were perhaps the pioneers in the distribution of power by motors. Our first experience was entirely with small motors. Certainly, looking at it from a standpoint of a company furnishing power, and the prices that we are getting for those motors, there is more money in the smaller ones than in the larger ones, beside their not being as hard on the dynamo, as Mr. Lufkin has stated in his paper. We have no very large motors in Philadelphia. In fact, the largest one there is a 5 horse motor running a saw as an exhibition, which is a very poor thing to use as a basis for figuring on. Motors that are upon fan work, in my estimation, are a very poor thing to figure on. It is steady work from morning till night and sometimes from morning to morning. It is a direct drag upon the current. We have but very few motors that are intermittent work. We have two that are on printing presses, and in all cases, I think, the motors that are doing that work have come up to the promises of the company putting them in. We only furnish a current for the motors; we have nothing to do with the motors themselves, excepting to bring the wire to them; we simply furnish the current. Once a month, however, we make a round of all motor places and inspect their condition, and see if there are any changes in the amount of current consumed by the motor. I do not know that I have anything special to say on the subject.

The President—To my mind, motors are the most important development at the present time in electric interests. If you will look around you and see the amount of capital that the various companies have put into this business in the last six months alone, you will find that it is something enormous, and you will find that the companies are not only going into it with the idea of supplying motors of 2, 3, 5, 10, 15 and 20 h. p., but they are going into it with the idea of developing and furnishing power up to 100 horse, and they propose to have, and are making generators to supply that power, to make it a special service; and not only that, but the increase of the factories already in operation is such, as to warrant the belief that they will, within the near future, be supplying generators of even much larger capacity than those named. Now then, if that is the case, if this development is going on, and the money is coming forth, it shows that the people who are putting this money in, have entire confidence, and that the management of these motor companies have entire confidence in the development of the business. This all means that we shall have stations which will employ probably 5,000 or 10,000 h. p. as centres of distribution. We go a step further, and

those centres of distribution furnish not only power for motor service, but they furnish power for railway service, and they not only furnish the power for railway service, but if the electric lighting companies do not take up this question, these very companies, formed originally for power distribution, will take up electric lighting. Now, that is the way it presents itself to my mind, and I had hoped that when this question came before this association this afternoon, the chair would be hardly able to hold down the number of people who would spring up all over the house and want to talk at the same time.

Mr. Ridlon—With yourself, Mr. Chairman, I am very much dissatisfied at not having heard more discussion upon this subject, because I expected electric light companies would come out and make statements in respect to the profits of the power business as compared with the profits of lighting. One thing I know to be a fact—there is quite a gain in that direction; and the power sold to the customer who uses the motor, costs the electric light people far less discount in their bills, gives them far less trouble, and they do not have to exercise that care or inspection that they have to with the lamps. I think one company in Boston have had but one dollar discount on their motor service, where they have had twenty on their lighting service.

Mr. Garratt—I was much interested in the remarks of Mr. Harding, but I was called out of the room, and did not fully hear them. I want to know if I am correct in my understanding, and if we can draw a general statement as to the power required for cars. I understood Mr. Harding to say, that cars are run on an average of sixteen hours a day, and on an average of 5 h. p. That means 80 h. p. hours per day, multiplied by 365—for cars run for 365 days a year—that makes 29,200 h. p. hours a year. I would ask Mr. Harding if it would be a fair statement to say that 30,000 h. p. hours per year, in round numbers, would run a car.

Mr. Harding—I think that would be a perfectly safe figure. The only excess might be that in certain cities they are liable to run one car possibly after twelve at night.

In order that there may be no misunderstanding in regard to what I referred to I would say that I was taking this condition: That the station was already established and had its engineers and firemen, and this was the additional expense for operating the street cars. I did not mean that the company put in this station and pay its engineers and firemen to accomplish this result. This was the additional expense of running cars from the central station.

Mr. Garratt—I understood that. I also understood Mr. Harding to say that an electric light station could afford to furnish a current for those 80 h. p. hours per day for about two dollars per car; that would mean $730 a year for a car. Let us put it in round figures—that wherever a local company wants to put in a 5 horse motor we can say we will let them have this for $800 a year for a car. Would that be a fair statement?

Mr. Harding—Yes, sir.

Mr. Ridlon—I will say for the benefit of Mr. Harding's company, that I was at Richmond with the West End Railroad people at the time they went on to investigate that question of electric railway service, and they were very much surprised at the low cost at which that power was furnished there per car. They could not possibly believe it, although I can see very plainly that it is a matter of fact; and they came to compare it with running horse railways, and they calculated it cost to feed a horse what it would take to run one of those cars a day—$2 a day, where it cost only $1.60 for the power from the electric light station; and that did not allow anything for the cleaning of the horses or the harness or the wear and tear of harness, or interest on amount invested for shoeing, or any other matters; but simply giving him his hay and grain.

Mr. DeLand—Referring to the paper by Mr. Leonard, of Minneapolis, on the use of petroleum as a fuel, Mr. Hart, of New Orleans, has kindly given me some data which may be of service, when we consider that his experience runs over nine months. It appears that the actual savings are over 50 per cent. in the use of oil fuel over coal. The data given me are these: They have been using first quality Pittsburgh nut coal, floated down the Ohio and Mississippi rivers costing $4.50 per ton laid at furnace door. The portion of coal that usually goes to waste costs 25 cents a barrel at Findlay or Lima, and 75 cents at the furnace. As three barrels of oil replace a ton of coal the saving is 50 per cent. There is no burning out of grate bars, no removal of ashes, no smoke in the boiler room. Mr. Hart said that the only disadvantage that they labored under was in respect to transportation. This difficulty they proposed to do away with by the construction of their own tank floats and depots. This company had their own tank costing $14,000. The oil flows from the cars into the receiving tanks, is pumped into reservoirs, passing thence through pipes under the boiler. When the oil is turned on a jet of steam is made to spread the oil flames, so that cold water is converted into steam in 20 minutes or less time.

You will remember that the question of the burning out of the grate bars came up during the discussion of Mr. Leonard's paper. Mr. Hart tells me that he has replaced the grate bars with brick, so that there is a saving effected in that respect.

Regarding the injury that might result to boilers, the fact that the inspector of a boiler company was down there a few weeks ago and approved of their system and congratulated them on their success, would show that there is very little probability of such injury resulting.

Mr. Hart has also kindly sent large photographs of their dynamo room, their furnace room, their engine room, and other parts of their large plant, and they are now in the parlor occupied by the *Western Electrician*.

The President—The chair is exceedingly sorry that he did not know before that the gentleman had that information in his pocket, for he would have called upon him for it. We are much obliged for this information.

Mr. DeLand—I would say, Mr. President, the thanks are due for these data to Mr. Morris J. Hart and Mr. Simon Hart.

Mr. Steuart—I would like to offer a resolution. During the first hour of the session this morning a very important question was disposed of, as I think, with inadequate consideration. The subject of the work of the New England Electric Exchange is one in which I have been very much interested for many reasons. I think it will be of great advantage to electric light companies in giving them competent employés. It also opens a field for honest and meritorious men to find good employment by procuring licenses from such an organization. I believe that during the morning hour the president of the exchange and secretary were, unfortunately, absent from the floor. They are now present, and I would move you that the action be reconsidered, the question opened for discussion, and the president and secretary requested to give us their experience and views on the subject.

Mr. Alexander—I am very thankful to my friend Mr. Steuart, for bringing this matter up again, less because I desire to give any information—I do not know how far you went this morning—but more to be able to state a grievance that I have. I asked the president of the association last night at what hour that paper would be read. The secretary of the association, the inspector of the New England Insurance Exchange were present and myself. We were very much interested in the subject, and naturally desired to be heard. I have stated to the president the nature of the business that called me away this morning and begged him to postpone that subject for a little while. I came here at 20 minutes past 10 and had no idea until 12 o'clock that it had been disposed of, although I was present here in the room at that time. Naturally I cannot say much, not knowing what the report has been; but I understand that there have been some statements made there which the secretary of the exchange, who has labored very hard in the matter, declares were not quite correct. As he knows what these misstatements are I will yield him the floor.

The President—The chair would just state that the statement of Mr. Alexander in regard to requesting a time to be appointed is correct. The chair will also state that every gentleman who has had a paper before this association would like to know the exact minute when it could be presented. The chair would also say that he does not know where gentlemen are to be found at any particular time, and that it is the duty of every member of the association to sit in this body from the time of the opening of the first session to the last moment of the last session. That is the only apology the chair has to make for any little inadvertence on his part. If he has failed to accommodate everybody it is simply because he could not look all over the City of New York and put the right man here at the right moment.

We shall be very glad to hear from the secretary of the New England Exchange.

Mr. H. B. Cram—The turn that this matter has taken, Mr. Chairman, has been somewhat of a surprise to me, and only within an hour did I know that the paper had been read. I had an opportunity of merely glancing at the paper—nothing further—and as in a very few moments I shall have to leave, I shall endeavor to make my remarks as brief as possible, and at the same time to convey some information which will be of interest to every member of the association. In New England we are pleased, I think I may say, with the Insurance Exchange, which has gone to work at the right end of the problem as to the relations existing between the insurance interests and the electrical interests. The electric light committee of the New England Insurance Exchange has for its chairman a gentleman who has devoted a great deal of his time to the subject, and from the start that exchange has evinced a very decided interest and determination to bring the insurance interests and the electric light interests into absolute harmony, in order that they may recommend what they believe the facts warrant them in doing, the installation of means of distributing energy by electricity, in preference to any way or purposes of illumination or of transmission of power. They have already taken several steps in that direction. They have offered a reduction in rates in certain cases where electric light is used as an illuminant in preference to gas or other means. When the matter of inspection was started, there was naturally more or less inertia, and it was finally discovered from experience that while the Insurance Exchange could inspect apparatus and installation it could not inspect men. As a result of that discovery the New England Electric Exchange was formed; to put it very briefly, in order to provide

some means for inspecting men. The exchange was formed as a result of a meeting, to which the insurance men were invited and the electric light men. The Boston Electric Club very kindly tendered the use of its rooms for the first meeting. After the formation of the exchange the New England Insurance Exchange, in order to give the matter authority said, "on and after October 1st the New England Insurance Exchange will require that all persons engaged in installing or operating electric plants, shall hold a license from the New England Electric Exchange." The Boston fire underwriters immediately indorsed that action. In a general way the plan was simply this: A plan of licenses was adopted, as I have already stated. Examiners were to be selected from men possessing theoretical and practical knowledge. The applicants were to be examined and passed upon by those examiners in order that the insurance people should be fully represented, and there might in no event be any question of the action of the exchange. It was decided that the inspector of the insurance exchange should countersign the insurance certificate before it was issued and became a certificate. I mention that fact thus particularly because I have observed that there has been an erroneous opinion existing. It has been thought by some that the New England Electric Exchange was simply the New England Insurance Exchange, and that they proposed to coerce electric light companies and electric power companies. There could be no greater mistake. The object is that the two exchanges should work in harmony, and our experience thus far has shown that while there may possibly be some crudities, nevertheless the plan is a good one and is practicable, and we are fully justified in saying there can be no possible question as to its ultimate success. Wherever a misunderstanding has existed it has been a matter of a very few moments' conversation to correct the misunderstanding.

After all that has been said during this convention about the absolute necessity of satisfying the subject that electrical energy can be safely distributed, it goes without saying, it seems to me, that there is an absolute need for some such body as the New England Electric Exchange. I believe that such exchanges should exist throughout the country. I further believe that they can only work in harmony with the insurance interests. I believe there is no other way in which their work can be made obligatory or binding. I believe in that way it can be made so, and without in any way interfering with the legitimate work of an electric company, whether light or power, or with the work or duties of any employé, from the highest to the lowest. We have found an increased interest among the employés. They feel that possessing a license, obtained after passing an examination, that their work will be better respected, that they will have the confidence of their employers, and also the confidence of the public. Our experience teaches us, I would say, in conclusion, that we are justified in predicting that, after the Electric Exchange has had time to fully demonstrate the purposes for which it is organized, there will be less heard throughout the public press of the danger to life and property arising from the electrical distribution of energy. [Applause.]

Mr. Steuart—Mr. President, I see that the time for the discussion of this subject has passed. Therefore I shall not attempt to add anything to what has already been said, but only to offer a motion that the committee that made a report to-day be increased to five members, and be continued, with instructions to bring in a report at the next meeting of this convention upon the desirability of establishing a national exchange in connection with this association; and I would respectfully suggest to the chair that the president and secretary of the New England Exchange be made members of that committee.

Mr. DeCamp—There seems to be a little difference here in respect to this report, and I find I am a member of that committee, and I plead guilty to a dereliction of duty. But I think the disposition made of the report offered by Mr. Ridlon, under the circumstances, is the best possible. As I understand, that report has been received and filed and the committee continued.

Mr. Steuart's motion was carried.

On motion of Dr. Moses the convention then adjourned till 3 o'clock, reconvening in the parlors of the Electric Club at that time, President Duncan presiding.

Mrs. Morrison, Mrs. Duncan and Mrs. Garratt were present.

AFTERNOON SESSION AT THE ELECTRIC CLUB.

PRESENTATION OF TESTIMONIALS TO MR. J. FRANK MORRISON AND MR. GEO. WESTINGHOUSE, JR.

Dr. Moses—It has been my pleasant duty, ladies and gentlemen, to be the depository of a secret for the last three months. You all know there is a certain pleasure about letting secrets out. It has been the desire of numerous friends of our honored first president of this association to exhibit to him in some way the esteem that they have for him, by giving him something that he might recollect, since he has frequently given them to recollect, while he was presiding over them, that would keep them always in mind. This time they have managed, I think, to embody something that will suggest to him something new every time that he looks at it; because a man's mind, after all, is suggestive and a man can find a world in a drop of water if he has imagination enough to see it.

There is crystallized in this box all the good feeling, appreciation and good fellowship that has actuated every member of the association towards Frank Morrison. We have tried to embody in this his life—and there is symbolically typified upon it something representative of the different phases of his active existence. In the first place we have started out the idea that it should be simple and strong: we have tried to paint this thing in black and white, and we hope that he will read between the lines in it all the good feelings that we have for him.

At the risk of being a little prolix I will explain the designs here, which represent, ladies and gentlemen, a good deal of hard work on the part of the principal men at Tiffany & Co.'s, who entered into it *con amore* I assure you. We see on a very simple base a silver box, having inscribed upon it this: "Presented to J. Frank Morrison by his friends of the National Electric Light Association, New York, August 31st, 1888." On this base we have three barriettes, one representing a continuous current machine, the centre one an alternating current machine, and the third a machine for the distribution of electric force. The first one is a Brush machine, and I think in the hands of Frank Morrison it did as much as anything else to establish the fact that electricity could be distributed from central stations profitably. In the centre we have a machine that was brought to the notice of the association at a time when he presided over it, and in the most advantageous way, as I recollect, to me, because he descended from the chair, took the part of the association, and defended them against innovation.

Third and last, but not least, there is a Baxter motor. Mr. Morrison represents the Baxter motor as head, front, president and everything else. It is a means of distributing force into something that he—so typical of him—has at heart, that by a very happy thought on the part of Mr. Whitehouse it has been embodied in a design so appropriate that he thinks of employing it for other purposes. All around you will find the Baxter motor worked up like a Greek honeysuckle. It makes a very beautiful decoration; so that the base of this thing is a Baxter motor. On the faces of this you will see Baltimore, whence Mr. Morrison comes; New York, where he receives this token; and on these sides are represented the places where all our conventions have been held—Baltimore, New York, Chicago, Detroit, Boston, Philadelphia, Pittsburgh.

By the bye, I must turn off the switch here in order to get at the key, that was introduced to typify in some way Mr. Morrison's connection with telegraphy, and through all the various progress by which he has reached the position of being the first president of the National Electric Light Association, which means not only the electric light but that upon which the electric light shines.

Here, sir (taking from the box a silver-mounted gavel and presenting it to Mr. Morrison), is an insignia of office that you have wielded so successfully at the head of all our conventions. The National Electric Light Association, I think, more than to any one else, owes its existence and successful development to you. It was by means of that little instrument, a symbol of power seldom used, except for good, that we would typify you with. We have been ruled by it, and we have frequently kissed the hand that bore the rod. Upon this is an inscription: "J. Frank Morrison—1885–1888; First President National Electric Light Association." Here is something typical of an electric cable, in order that you may with this in your hand hear yourself in contact with every one whom this is intended to govern. This is an insulator. The president must be insulated from all the influences that prevail on the floor of the assembly. [Applause.] And we thought that to have been the best symbol that we could put upon the gavel.

Here, sir, you have a cable surrounding this, which represents, strand by strand, that by some attachment of the heart every member of the association is in close contact with you, and always on the call.

Here is your monogram surrounded by a laurel wreath, which you deserve; each leaf represents, by the skill of the silver beater, an incandescent lamp, and the whole of it blossoms, at the top, into light. On this side you have an arc light—a Brush arc light, which you first tried, I think, in Baltimore, before the public, in a successful way; so that I think that we have, in this respect, typified all your connections with electric light interests, and here is the key of it, which is also the key to our hearts. You will find that it is made of wire, and it is a short circuit to us. [Applause.]

Mr. Morrison—Mr. President, Ladies and Gentlemen:—"They say that the most trying time to the soldier is when he is under fire and cannot shoot back. I take it for granted that those of you who have been brought suddenly into a position of this kind, can have some little sympathy with the soldier. The fire of compliments that I have received for the last fifteen minutes is enough to break the nerve of a man of much more self-possession than myself. In discharging the duties devolving upon the president of the Electric Light Association, I have not always been able to do that which would, as Dr. Moses suggests, make them wish to kiss the hand that wielded the rod. I think they felt more like having that rod themselves a little while sometimes.

But a man can discharge a disagreeable duty honestly, and will at the end of it get from all fair minded men that reward which is always better than anything else—fair treatment in return.

"My connection with the National Electric Light Association has been a very pleasant one. It has been a sort of channel through which I have made friends in every part of the country. It makes no difference whether I am in Maine or Texas, I find members of the National Electric Light Association, an organization which was born only four or five years ago. I find friends spread all over the country, and in every case extending a hearty greeting and a hand of friendship. In that way I feel amply repaid for all the troubles that fall to the lot of a presiding officer. It has made the labor of the president of the National Electric Light Association a labor of love, and the appreciation which the gentlemen of this association have shown for my poor endeavors are ample payment. It was not necessary to present me with so valuable a gift to make me carry the memory of every one of you in the most kindly manner in my heart. The National Electric Light Association is still something like a young bear—a good deal of its troubles are ahead of it, and if you have not committed an error to-day in some of your legislation, I think that a new generation will fill the vacant places, which men of our time of life must soon make in the ranks of the membership of the National Electric Light Association, and these men taking up the work as we leave it off, will turn back to the records of the association and will find, although it was born in storm, it was at this time pursuing its vision calmly and harmoniously. This association was born in storm and under the most peculiar circumstances of suspicion and jealousy. That sounds strange, doesn't it, to you men who are so friendly to each other to-day. The organization of the National Electric Light Association was made by men who, not expecting to gain any benefit, were afraid to ignore a call which was made for electric light men to meet in Chicago, for fear some other fellow would get a benefit they did not possess. Yet that most sordid motive has led to the most favorable results.

"Only a few hours have slipped through the hand of time, since I was made the recipient of a gift and testimonial, handed to me on the floor of the association under circumstances, which make it most embarrassing for a man to say what he ought to say; and here I find myself brought face to face with a most expensive gift—the gift of gentlemen to whom I have not always been exactly kind, I believe, though,—I hope—I have been just. You can understand, therefore, that in rummaging through the junk-shop of my head for something suitable to say, it is not easy to find the kind of metal you need, so whatever breaks there are in my talk, you can just charge to that, and ask yourselves if you would be able to do anything better if you were in my place. My position, I confess, is a most embarrassing one, one in which, in the future, if I am on a committee, and I have the honor of presenting to the retiring president of the association a testimonial, I pledge my word of honor I will never place him. I thank you for your courtesy; I thank you for the kindness you have shown me through our course of electrical tribulations.

"I thank you for all the kindness you have shown me during all these years. It is not necessary for me to tell you that I will remember it as long as I live, for I could not possibly forget it if I tried, and I would not if I could.

"Before I step back, I want again to call your attention to a remark I made a moment ago. Within the next twenty-four months will be determined the question whether the National Electric Light Association will become a permanent institution, or whether it will pass away, as thousands of other associations have passed away, leaving hardly a trace. This, to-day, is the strongest electrical organization ever gotten up in this country. It is not strong in members, but it is strong in its firmness of purposes and it is strong in the intentions of its members up to the present time. They, I am happy to say, have been able to eliminate every feeling of personal advantage, and have met upon a common footing; now, with that feeling, I say, guard yourselves against suspicion, against jealousy, and whenever a question comes up which you will be called upon to decide, think first, not what will this do for me; you, gentlemen of New York, do not stop to think what it will do for the New York Electric Club. You, who are engaged in the wire business, do not say what will this do to the advantage of my business; but knowing and feeling that neither social organization nor private business can be advanced or live unless you act on the basis of fairness and honesty, when these questions come up, give and take until you get a synchronism along the whole line.

"This is the first chance I have had in my life of talking before ladies. I have only fear of one. (Laughter.) One of the difficulties of a man untrained in speaking is the difficulty, not of what to say, but where to stop. I never have been able to find that point, and so have to break off just as abruptly as I do now. Gentlemen, I thank you." (Applause.)

Dr. Moses—There is one other very pleasant duty that has been thrust upon me like greatness upon many men, and if Mr. Byllesby is here, the representative of one of the Westinghouse interests, which contributed so pleasantly last winter to entertain us while in Pittsburgh, I would be glad to say to him what I have to say. (Mr. Byllesby was not present.) Well, as our honored president lives in the same town as Mr. Westinghouse, I would be glad to address him, or if the president of the club will accept the gift for Mr. Westinghouse, it will serve our purpose.

This, gentlemen, is a little testimonial from the association. I will not say a receipt in full, but a receipt on account of the National Electric Light Association for many kindnesses extended by the interests represented by Mr. George Westinghouse, Jr. The inscription, however, I think, will convey in a very few words, just exactly what was intended to be conveyed: "George Westinghouse, Jr., from the National Electric Light Association, in grateful recognition of numerous attentions and substantial favors extended by his various companies during the Pittsburgh Convention, February 21st, 22d and 23d, 1888. Presented New York, August 31st, 1888." I would like to recall to your mind that Mr. Westinghouse's company, in a very delicate way, sent us quite a number of checks which amounted in the aggregate to some $1100 or $1200, which were accompanied by the express wish that the subscription might contribute in some way to the publication of the valuable proceedings of this association. The best return we can make for the field given to us is to present the donor with the fruits which it produces, and we have here a copy of our transactions bound, in, I hope, an appropriate way to convey at least, our delicate sentiments to him. They are contained in a case, that he may keep by him in such way as to remind him from time to time of his relations to this association, and how they were pleased to enjoy his hospitalities. Gentlemen, if Mr. Byllesby is not here, we will then send the box to Mr. Westinghouse, with the compliments of the association.

The convention then adjourned.

The following is a list of gentlemen present during the convention:—

Auburn, N. Y.

Simpson, F. C.

Baltimore.

Colvin, F. R.
Evans, D. E.
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Wilkes, Gilbert.

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Clark, Walter P.
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Schaefer, L.
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Hochhausen, Wm.
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Buffalo.

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Huntley, C. R.
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Fort Wayne, Ind.

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Mace, Theo.

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Johnson, H. H.
Waterhouse, F. G.
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Houghton, Mich.

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Jacksonville, Ill.

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Johnstown, N. Y.

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Montreal, Canada.

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Cadwell, W. D

Nashville, Tenn.

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McIntire, C. H.

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Newton, Mass.

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New York.

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Conkling, Addison.
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Cullen, W. F.
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Eliot, J. F.
Field, C. J.
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Gibbens, D. L.
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Stone, Frank G.
Stump, C. E.
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Walker, Major.
Western, B. R.
Wetzler, Joseph.
Wheeler, Dr. S. S.
Wiley, G. L.
Wilkins, F. H.
Wilcox, C. H.
Williams, J.
Wilson, E. W.
Wirt, C.
Worthington, George.

Niagara Falls, N. Y.

Rhodes, B.

North Attleboro, Mass.

Dillon, T. W.
Daggett, H. M., Jr.

Orebro, Sweden.

Wenström, Jonas.

Paris France.

Abdank-Abakanowicz, B.

Pawtucket, R. I.

Stenck, S. G.

Paterson, N. J.

Halsey, ——
Noonan, J. F.

Philadelphia, Pa.

Brooks, David.
Cleverly, H. A.
DeCamp, A. J.
Dunton, A. L.
Garnett, J.
Heinrich, R. O.
Hering, Carl.
Houston, E. J.
King, C. C.
Law, M. D.
Moore, A. F.
Scott, E. A.
Simpson, J. R.
Smith, T. Carpenter.
Smith, W. F.

Pittsburgh, Pa.

Acheson, E. G.
Baxter, G. H.
Byllesby, H. M.
Duncan, S. A.
Porter, Geo. F.
McGonnigle, R. D.
Mead, M. M.

Plainfield, N. J.

Moore, A. V. H.

Portland, Me.

English, J.

Poughkeepsie, N. Y.

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Carman, Henry.

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Redman, G. A.

Rutland, Vt

Francisco, M. J.

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Knudson, A. A.

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Russell, D. R.

Syracuse, N. Y.

Seymour, A. P.

Taunton, Mass.

Mitchell, D. L.

Tokio, Japan.

Fee, Hasegara.

Toronto, Canada.

Morrison, W. J.

Trenton, N. J.

Angell, F.

Troy, N. Y.

Minahan, J. C.
Pratt, R. J.

Utica, N. Y.

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Cartwright, F. G.
Vanderbois, H. S.

Waltham, Mass.

Leonard, F. H.
Marsh, E. A.

Washington, D. C.

Royce, F. W.

Windsor, Conn.

Baird, M. E.
McIntire, W. C.
Newton, A. D.

Wilmington, Del.

Hoffecker, J. S.

Woburn, Mass.

Lear, G. R.

Worcester, Mass.

Smith, A. M.

Youngstown, Ohio.

Coombs, C.

EXHIBITS.

During the convention exhibits were made, in various parlors and rooms of the Hotel Brunswick, by companies and firms as follows :—

American Electrical Works, Providence—Insulated wires and cables.

The American Waltham Watch Co.—Non-magnetic watches.

The Baxter Electric Manufacturing and Motor Co., Baltimore—Photographs illustrating the use of the Baxter motor in many places where they are now employed.

The Bernstein Electric Manufacturing Co., Boston—Series incandescent lamps.

The Callender Insulating and Waterproofing Co., New York—Solid underground system and "Trinidad" line wire.

The Campbell Electrical Supply Co., Boston—"Vulcan" wires and cables.

The Eddy Electrical Manufacturing Co., Windsor, Conn.—Electric motors and speed indicators.

The Electrical Accumulator Co., New York, and **The Electro-Dynamic Co.,** Philadelphia—Storage batteries and appliances.

Electron Manufacturing Co., New York—Dry batteries.

The Eastern Cable Co., Boston—"Clark" wires and cables.

The E. P. Gleason Manufacturing Co., New York—Electric light shades, globes, etc.

The E. S. Greeley & Co., New York—General electrical supplies.

C. K. Giles, Chicago—Anti-magnetic shields for watches, and experimental apparatus illustrating their operation.

The Grove Electric Co., Philadelphia—Meters for lamp-hours.

Hill Clutch Works, Cleveland, O.—Couplings and pulleys.

Hurlbut Flexible Conduit Co., New York—Flexible conduit for underground wires.

C. L. Ireson, Boston—Leather link belting.

A. B. Laurence, Representing the Underwood Manufacturing Co., Tolland, Conn.—"Cotton-leather" belting.

Law Telephone Co., New York—Batteries for telephones.

Locke Brothers, Salem, Mass.—Damper regulator.

C. McIntire & Co., Newark, N. J.—Joints and connectors for electric wires.

National Conduit Manufacturing Co., New York—Conduit system.

The New York Insulated Wire Co.—"Grimshaw" wires and cables.

Non-Magnetic Watch Co., New York—Paillard non-magnetic watches.

The Okonite Co., New York—Insulated wires and cables.

The Phœnix Glass Co., New York—Electrical glassware.

E. E. Pettingill & Co., Boston—Electric light, telephone and telegraph supplies.

James W. Queen & Co., Philadelphia—Electrical testing instruments for both laboratory and practical use.

The Standard Carbon Co., Cleveland, O.—Electric light carbons.

The Standard Underground Cable Co., Pittsburgh—Insulated wires and cables.

Standard Paint Co., New York—Waterproof and preservative paints and compounds.

Sprague Electric Co., New York—Their latest form of motor.

The Schenck Belt-holder and Shifter Co., New York—Model of belt-holder.

The Sawyer-Man Electric Co., New York—Incandescent lamps, fixtures and appliances.

The Simplex Electrical Co., Boston—"Simplex" wire and insulators.

The Stilwell & Bierce Manufacturing Co., Dayton, O.—Photographs of their "Victor" turbine.

A. Schoverling, New York—Dry battery.

Chas. A. Schieren & Co., New York—Electric leather belting.

The Thomson Electric Welding Co.—Specimens of electric welding.

Union Indurated Fibre Co., New York—Battery jars, conduits, etc.

Western Electric Co., Chicago and New York—Long-distance telephone desk, with telephonic connection with the city exchanges for use of members.

T. Wallace, Ansonia, Conn.—Conduit for electric light wires.

THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS.

PUBLISHED MONTHLY AT

11 Wall Street, New York City.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies, -		.30

[*Entered as second class matter at the New York, N. Y., Post Office, April 9, 1888.*]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, *11 Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers.*

VOL. VII. NEW YORK, OCTOBER, 1888. No. 82.

SUBWAYS AND COMMISSIONERS.

NO topic occupied so much time and attention at the recent electric light convention as the underground wire question. The pointed and pithy address of Mayor Hewitt, on the opening of the convention, was a sort of "key note" as the politicians say, and would have served to concentrate the minds of the assembled electric light men upon subways and subway commissioners even if the members of the association had not come to New York with their heads full of the subject.

New York having enjoyed the advantage of having a subway commission for some four years, was, not unnaturally, expected to offer the gathering of the electric lighting fraternity some reasonably satisfactory solution of the underground wire problem. What then was the general surprise when His Honor the Mayor called upon the association to put their wits at work on the subject and to tell New York and its Subway Commission what to do with arc light wires?

Notwithstanding the value and interest of the papers and discussions that followed, on various aspects of the question, it is needless to say that the Electric Light Association offered no solution of the problem in response to the Mayor's request. They contented themselves by a resolution of "hearty sympathy with the views expressed by His Honor, Mayor Hewitt," and including an expression of the "opinion that up to the present time no commercially practical method has ever been brought to their notice by which high tension direct currents, such as are used for arc lighting, can be placed underground." We take the liberty of saying that a resolution recommending the immediate discontinuance and abolishment of the Subway Commission would have been much more to the point, and not less in accord with the Mayor's convictions as expressed and implied in his address. In fact, we believe that much competent opinion would be found to favor the suppression of that ridiculous body, as a wise preliminary step towards a satisfactory solution of the electric wire question. However desirable such measure might be, it is not likely to be accomplished, for, as Mr. Hewitt remarked, the commission was made up of men supposed to understand politics though they knew nothing of electricity. They have known enough to promote the organization of a company to construct, own and control the conduits and to rent them to the electric companies. This is undoubtedly the most objectionable feature of the situation from the point of view of the electric companies, or at least such of them as are not shareholders in the conduit company; and their objection is well founded.

The commission has distinctly failed to accomplish the purpose for which it was created, to wit: the adoption of a general system of subways for all the electric wires of the city. In view of the imperfect state of knowledge and practice on this difficult problem, the failure of a board of politicians to solve it is not at all surprising.

In several other cities, notably in Chicago, electric lighting companies are putting down their own conduits, and gradually, by the aid of knowledge and experience, reaching sound and trustworthy methods. They do not suffer from the lack of a Subway Commission. We believe electric light men now generally recognize the ultimate necessity, and even ultimate economy, of underground conductors; and that in their hands the difficulties of the work to be done are far more likely to find solution, than in the hands of such a body as the New York Subway Commission.

There can be no doubt of the necessity of the regulation and control of electric wires on the part of the municipal authorities. The tardy recognition of this need is already bearing fruit in the work of removing dead poles and wires and establishing something like order among overhead wires, recently begun by the commission under the lead of its expert, Dr. Wheeler. They may well suspend underground work and find more useful employment for some time to come in regulating existing pole lines.

Although this work could be done just as well under the direction of an expert, by the Department of Public Works, yet, inasmuch as we have the commission, and it seems to have come to stay, let it be made useful.

PROFESSOR RICHARD A. PROCTOR's death creates a noticeable void in the ranks of scientific workers and writers. Through his long continued and successful work in bringing scientific knowledge and methods of inquiry before general readers and the public, in his writings and lectures, he became very widely known and appreciated outside of scientific circles. He did not disdain ordinary topics, and discussed the game of whist with scarcely less interest and vigor than he displayed in his astronomical writings. He showed little of the impersonal

tone characteristic of the highest type of scientific mind. His more personal or intimate style was exceedingly well adapted to make scientific discussion attractive to the general public. The usefulness of his work is undoubted. It is gratifying to recall the success and high estimation which he achieved in the United States.

It is rather too bad that nearly all, if not all the journals which reported the recent convention of the National Electric Light Association, except the Electrical Engineer, should have spoiled the point of the felicitous quotation of Dr. Arnold used by Dr. Moses in his report as chairman of the executive committee—viz., "A teacher is a man who is striving all the time to make himself useless." Either stenographers, reporters or editors thought this could be bettered by writing "useful" instead of "useless," and gratuitously made the alteration. In the discussion on fuel, following Mr. Leonard's paper, on "Petroleum Fuel," Mr. E. R. Weeks, of Kansas City, having stated that his coal cost $2.56 per ton, was asked what kind of coal he used, and his reply is variously reported as "not bituminous" "non bituminous" and "bituminous" instead of "bituminous nut," as it stands correctly in the Electrical Engineer Extra, of September 15. These errors are not of great importance, but they illustrate the difficulty of reporting proceedings accurately in a race for priority of publication.

Why would it not be a good plan for the New York Legislature to complete and round off its capital punishment by electricity act, at its next session, by creating the office of Lord High Executioner for the state, and including an enactment that Harold P. Brown, Electrical Engineer, shall be appointed to the office for life or during good behavior?

The 28th meeting of the American Institute of Electrical Engineers, and the first of the present season, will be held at the house of the American Society of Civil Engineers, 127 East 23d street, on Tuesday, October 9, at 8 o'clock, P. M.

The programme of the evening will be the discussion of Mr. Frank J. Sprague's paper, on "The Solution of the Municipal Rapid Transit Problem," which was read at the last special meeting of the Institute, June 19, last. Messrs. M. B. Leonard, of Richmond, George W. Mansfield, of Boston, and Robert W. Blackwell, of New York, have signified their intention of taking part in the discussion, and other members who have made a study of the subject are expected to be present and participate.

The meetings of the Institute are open to all who desire to attend, and it is hoped that many persons who are not members will be present at the next meeting. The officers and managers of street railways will find much to interest them in the discussion.

At the recent meeting of the British Association for the Advancement of Science, no less than 37 papers on electrical subjects were read. The authors comprised men distinguished in electrical research, invention and practice, their topics covering a wide range of both theory and application. With all this wealth of scientific and technical knowledge Great Britain has, says Professor Ayrton, hardly 100 electric motors in use while America has already 6,000. We must still admit that our English brothers keep ahead of us in research and theoretical discussion, but we somehow get electrical contrivances made, tried and in commercial operation before we know much about their theoretical properties.

Our slap-dash manner of plunging into business with new electrical devices has, of course, its disadvantages, and would be disastrous, perhaps, but for the freedom of movement and recuperative resources attendant upon our industrial conditions. We learn from experience, more than from theoretical considerations, to revise our methods and to reconstruct our machinery; experience which, however costly, is seldom ruinous. From the establishment of the telegraph down to the commercial introduction of electric lighting and motive power, the course has been the same, viz.: doing the work at first "by main force and violence," to use the language of an old telegrapher. In the case of the telegraph it took us over 20 years to find out how much trouble and money could be saved by adequate attention to a few elementary electrical principles, —but meantime we had established the most widespread and general use of telegraphic communication in the world. In the more recent industrial applications of electricity, particularly in electric lighting, the displacement of crude methods and the adoption of sound principles of construction and operation have come much more speedily than in the case of the telegraph, though much yet remains to be done, particularly in the matter of line construction.

When rough or inadequate methods or construction jeopardize human life, the rapid development of a new industry is purchased too dearly. Two runaways of an electric street car within a fortnight, down the same steep hill on a city railway route, are at least one too many. The plunge of a motor and car down Mount Oliver, at Pittsburgh, August 13, severly injuring the conductor and a lady passenger, was a sufficient warning; but on the 28th of the same month a motor and car escaped control and ran down the same hill, both motor and car being wrecked and seven persons injured badly, one, as reported, fatally. Failure of mechanical appliances for controlling the descent is alleged as the cause of the disasters.

In the number for January last, the Electrical Engineer, commenting on electric car machinery, said :—

> A well-known electrician of our acquaintance had occasion a short time since to consult a manufacturer of locomotives, whose street railway motors have attained a national reputation for economy and general efficiency, with reference to the construction of an electric motor. The manufacturer at once exclaimed that it was useless for him to estimate on electric machinery, as he had found by experience that electrical people would not pay for the quality of workmanship that was required for proper locomotive running gear. What they wanted, he said, was a cheaper class of work, such, for example, as that used in a rather poor grade of agricultural implements.
>
> * * * * we have noted a certain disposition on the part of some electric railway people to undertake what may be called feats of sensational engineering, such as running over imperfect tracks, and up and down impracticable gradients, and the like. There is no reason whatever to suppose that an electrically driven locomotive can run with safety where a steam driven one cannot, yet it is quite apparent that many people who ought to know better are being carried away with the delusion that any railway

problem that presents peculiar difficulty can be solved at once by the application of electricity.

THE establishment of an office and headquarters of the National Electric Light Association in New York, under the permanent charge of an electrical engineer as secretary and treasurer, determined upon at the August meeting will soon be an accomplished fact, and cannot fail of usefulness to the association. It is understood that Dr. Allan V. Garratt, of Boston, will accept the charge of the office, and will soon remove to New York to assume the duties of secretary and treasurer. Dr. Garratt will be cordially welcomed to this city.

OBSERVATIONS.

NEWSPAPER science still flourishes in Canada as well as in the United States. There recently fell into the observer's hands a copy of the Montreal *Herald*, in which was a special from London, Ontario, to the following effect:—

"Sept. 17th.—Harry Walker, an employé in the Ball electric light station, had a narrow escape on Saturday night. He happened accidentally to form the connecting link for the electric current, and was knocked insensible. *When two policemen picked him up his body was so full of the fluid that they both received bad shocks.* He was finally taken out of the station and placed on the ground, and soon came round."

One notes the completeness of this account, its *multum-in-parvo*-ness so to speak. We are driven to one of two alternatives. Either we must go back to the fluid theory of electricity, or we must assume that the fluid with which Mr. Walker was filled, and which shocked two policemen, was not electric fluid but some other fluid.

Further, that the operation of laying Mr. Walker upon the ground appeared to subserve the desired purpose of discharging him.

. . .

THE above utilization of the earth as a discharging train, calls to mind the recent reading of some Western historical notes, in which the discovery of the earth return was attributed to Messrs. Reid, Reilly, and O'Connor. As might have been expected Mr. Reid comes to the front with a disclaimer, which is embodied in some most interesting historical notes.

The electrical use of the earth is, in fact, much older than telegraphy, and formed an element, albeit an unrecognized one of Stephen Gray's experiments on conduction.

As early as 1746 Winkler discharged Leyden jars, using the river Pleisse as a discharging rod. Le Monnier, Watson, Franklin, and De Luc successively made similar and more exhaustive experiments, and fully verified these results. These were, however, all experiments with high potential electricity frictionally developed.

Basse, of Hameln, in 1803, used water and damp ground to form part of a battery circuit.

Basse was followed in the same year by Erman, of Potsdam; Aldini, of France; and eight years later Soemmering and Schilling.

Steinheil used the earth as a return wire for a telegraph line in 1837, and was the first so to do; but the most remarkable prior suggestion was that of Faraday, contained in his note 292, series iii.; which states, "A good discharging train was arranged by connecting metallically a sufficiently thick wire with the metallic gas pipes of the house, with the metallic gas pipes belonging to the public gas works of London; and also with the metallic water pipes of London. It was so effectual in its office as to carry off instantaneously electricity of the feeblest tension, even that of a single voltaic trough, and was essential to many of the experiments.'

It appears that Faraday used as early as January, 1833, the date of the above note, gas and water pipes as grounds just as we do now.

There are lots of things in Faraday's experimental researches, that have since been invented.

. . .

IT is gratifying to note by the paper of Mr. E. R. Weeks (read at the recent electric light convention) that the necessity of thorough electrical education is recognized at Kansas City. The Gramme Society of that place moves ahead in the right direction. The spread of such societies will probably tend to increase the class of men who have found out that with increased knowledge they don't know as much as they thought they did, when they thought they knew it all. But when they reach that stage they will be better workers and better citizens.

. . .

THE observer sees that a new electrical paper has appeared in Kansas City, entitled the *Electro-Mechanic.* Volume I., No. 2, gives the interesting paper of Mr. Weeks in full.

It may be conjectured that some one connected with the *Electro-Mechanic* has, in the dead past, been one of that misguided class who have infringed the patents of the Bell Telephone Company, and who have, in consequence, felt the heavy legal hand of that company, for we find that in the list of books owned by the Gramme Society, according to the *Electro-Mechanic*, is Prescott's "*Hell's* Speaking Telephone."

. . .

THE West End Railway Co., of Boston, wants to apply electricity as a motive power wherever it can; and it wants, in some aristocratic districts of the Back Bay, to use the overhead wire system. Although the said company tries its best to make the adjacent residents believe that an overhead wire and its supports for an electric railway are things of beauty and joys forever, some of them stubbornly refused to be persuaded, and at a recent meeting of residents in remonstrance, Frank Morrison, for himself and others, appeared, and among other startling statements delivered himself of the following. "The centre wire must be insulated its entire length, a new thing on our streets, *so that if touched by a man it will pretty near kill him.*"

What an age we live in to be sure.

. . .

HERE is an observation thrown in *de bene esse.* A Tennessee negro (says a Nashville newspaper) has just been put in prison for being too smart. He couldn't see why he as well as others should not practice on the negative side of electricity. His crime was selling glass marbles to his "cullud brudders," as a protection against lightning. He stated in making his sales that they were made from glass telegraph insulators from which they derived their efficacy, and his price for each marble was 40 cents. Perhaps this nice little business *was* a little crooked, but the enterprising darkey does not understand why he should be singled out for incarceration and other quacks go free—nor indeed does the observer.

. . .

A PROPHET is necessarily an observer; if he is not, his prophecies will not in the end be profitable.

But the observer is not a prophet. He does not daily predict the wonderful things which are to be hereafter accomplished by electricity.

Nevertheless he desires to state that the patents for electric railways and locomotion issued from the United States Patent Office during the month of June 1888 alone, are approximately equal in number to one-third of the entire list of similar patents issued during the year of grace 1886.

. . .

JOURNALISTIC enterprise—in the business department—can be said to have reached the dignity of a high art in the following instance. The observer notes that the New York representative of one of our bright periodicals has secured the services of two assistants; one of whom is a tenor soloist of acknowledged ability, and the other an assistant editor of an orthodox religious publication.

ARTICLES.

THE COPPER VOLTAMETER.

BY LIEUT. G. L. ANDERSON.

When ordinary care is taken, copper electrolysis affords the means of standardizing current measuring instruments with great accuracy. The limit of error need not exceed $\frac{1}{50}$ of one per cent. which is far within practical requirements. Results in still closer agreement can, no doubt, be obtained by the silver process, but the copper voltameter requires less skill and labor in manipulation, costs less to purchase and use, and it is sufficiently accurate through a greater range of current strength, current density, density of solution and temperature.

It consists briefly of two series of parallel copper plates suspended vertically in copper sulphate solution. If a uniform current be sent through the solution from the plates of one series to those of the other, the weight in grammes of copper deposited on the latter in one second divided by .0003287 will, if the requirements are fulfilled, be the strength of the current in amperes and the value of the deflection of a galvanometer in the circuit. The divisor will differ slightly from .0003287 if the temperature or current density vary much from the normal.

For currents less than five amperes, the ordinary cylindrical battery jar may contain the solution and support on its rim rectangular cross-pieces, each having a brass spring or wire clip bearing at the middle for holding a plate. Or the plates may suspend from the cover. Three plates—two, anode and one, cathode—are each cut from rolled sheet of pure hard copper into a circular or rectangular form, having a tongue piece (3 × 2 cms.) The edges and the corners, if any, are rounded off and smoothed. Usually the cathode is two or three centimetres longer and wider than either anode, and should be as thin as possible, and yet sufficiently stiff so as not to be bent in cleaning. The tongue piece projects from the middle of a side of the plate, and in position is held by the spring on the cross-piece. It is the only part of the plate above the surface of the liquid. The cathode is suspended between the anodes parallel at about a centimetre distance, and insulated from them.

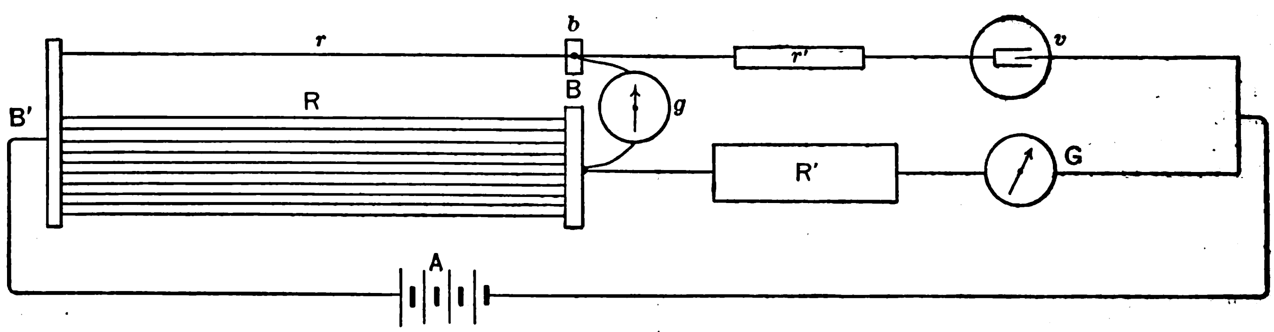
For large currents the size or the number of the plates may be increased. If the latter, there will be one more plate in the anode than in the cathode; the plates of one will alternate with those of the other, and will be insulated from them as above. The Germans use platinum for the cathode, and the results obtained with it agree with those from copper to within $\frac{1}{5000}$.

The cleaning of the plates prior to immersion, and the washing subsequent to it, are important operations requiring only a short time if properly done. The cleaning consists in polishing the surface with fine clean, dry sand paper, which is wrapped about a wooden cylinder and revolved in the lathe. The plate is held tightly against the cylinder by means of a pad to avoid touching the surface of the plate with the fingers. The dust is then wiped off with a soft brush or silk pad, or washed off in clean water. If slight oxide remains, as shown by the coloring, the plate is put in slightly acidulated water. If thickly oxidized, as with new copper, it is wetted and placed a few seconds in strong nitric acid, then washed under the spigot and, in order to prevent oxidation, put in a tray to which a few drops of acid have been added. The anode is first suspended in the bath. The cathode is rinsed off and dried, first between two sheets of filter paper and, afterwards, by a current or before a fire or lamp (not over them). When cooled to the temperature of the air it is weighed and at once suspended in the solution.

As soon as the deposit is made the plates are removed, washed in pure water slightly acidulated, and placed in a tray of distilled water. The deposit on the cathode ought to be firm and even, but if there are any crystals projecting care must be taken not to knock them off in washing. This plate is immediately rinsed, dried as before, and when cool weighed. The gain of metal should exceed a gramme.

Special care is taken in cleaning and washing the cathode, which is the only plate weighed. The loss of weight by the anode is usually greater than the gain by the cathode, the difference going to strengthen the solution. Unfortunately the loss is too irregular to be used even as a check.

The solution should be of pure, or good, commercial copper sulphate, free from iron, and have a density anywhere between 1.08 and 1.18. Three to five parts by volume of concentrated solution (density, 1.21) to one of clean water are recommended, with one per cent. sulphuric acid added if the solution is not sufficiently acid from the salt. There should be three cubic centimetres of liquid for every square centimetre of surface—counting one side of all the plates—and it may be used ten hours before throwing away. If the density is much less than 1.08 the deposit is less adherent, and if greater than 1.18 there is danger of the solution becoming saturated, causing, in the first place, oxidation which increases the gain of the cathode and, secondly, the formation of sharp crystals at the edges.



The solution must be kept distinctly acid to retard its action on the plates. It is found that copper metal in the sulphate solution loses and, sometimes by oxidation, gains weight in an irregular way. The action appears to be greater when a current is passing; it is slightly less for densities between 1.10 and 1.15, but never wholly ceases, and with acid present it may amount to $\frac{1}{500}$ of a milligramme per square centimetre per hour. The error from this source will not exceed $\frac{1}{50}$ of one per cent. The objections made against the copper voltameter have been this uncertain loss of plate in the solution, and its tendency to oxidize after it is withdrawn and before it is weighed.

The results of many experiments indicate the best size of cathode to be that which presents about 100 square centimetres to every two amperes, or at that rate. In other words, the current density should be about .02. It may be as high as .02½, but if it much exceeds this figure there is liability of sharp crystals forming on the

edges after 20 or 30 minutes, a weakening of the solution next the anodes and fluctuation of current from temporary polarization. With diminished current, as low as .003, the deposit is firm and even, but slightly less than it ought to be. It may, therefore, be used if we take a number smaller than the electro-chemical equivalent for a divisor, as shown in the table. The objection to small current density is that it increases the relative amount of error due to the action of the solution on the plates, leakage between the plates, oxidation of deposit after its removal from the bath, errors of weighing, and so on.

Increase of temperature is likewise found to diminish the proper gain of weight by the cathode, and correction is made as above by taking a smaller number for the equivalent from the table. The effect is slight for changes at ordinary temperatures and greater at 30° or 35° C.

The rule for getting the current strength in amperes, then, is to divide the weight in grammes deposited in one second of time by .0003287 when the density of the solution is between 1.08 and 1.18, the current density about .02 and the temperature about 12° C. For other densities and temperatures take the divisor from the following table, given by Mr. Thomas Gray, to whom and to Dr. Kittler we are indebted for the development of the copper voltameter as a means of calibrating current measuring instruments:

TABLE.

Sq. cms. of cathode per ampere.	Current Density.	2°C.	12°C.	23°C.	28°C	35°C.
50	.02	.0003288	.0003287	.0003286	.0003286	.0003282
100	.01	8	84	83	81	74
150	.006⅔	7	81	80	78	67
200	.005	5	79	77	74	59
250	.004	3	78	75	68	52
300	.003	2	78	72	62	45

If the voltameter is suited to the current strength, or can be adjusted to it by changing the size or number of plates, it is joined in simple series circuit with the galvanometer to be calibrated, a mercury key, a small extra resistance, and a constant battery. The extra resistance which may consist of a strand of wire on two rollers, as in the Thomson pattern, or of this rheostat joined in parallel with a few coils, is intended to keep the current uniform by more or less of it being thrown in or removed from the circuit. If the current is small, tray cells in series furnishes a steady current, and a high electromotive force is desirable. In case of large currents, accumulators are usually employed. We can previously determine the number of cells and the best method of grouping to give the necessary current with a portion of the extra resistance in circuit. The voltameter resistance will be about 25 ohms divided by the number of square cms. on one side of the cathode.

If the voltameter is for small and the galvanometer for large currents, the circuit is arranged as in the diagram.

R and *r* are straight german silver or platinoid wires or strip, eleven for example, having equal resistance, and connecting the heavy copper blocks *b*, B and B′. One or more of the wires terminating in B may be shifted to *b* as required. Blocks, *b* and B, are connected by a sensitive zero galvanometer, *g*, some distance away to indicate whether or not they are at the same potential. If they are not, the potential of *b* is adjusted to that of B by means of the rheostat, *r*, next the voltameter, *v*. B′ is a heavy current resistance for adjusting the galvanometer G (to be calibrated) to the required deflection. Accumulators, A, supply the current. With ten wires in R and one in *r* and *b* and B at the same potential, the current through G will be ten times that passing through the voltameter.

If the voltameter is for large and the galvanometer for small currents, G and *v* in the diagram replace each other; or the "shunt" arrangement (shown in the January number of this journal, 1885) may be used.

The operation is sometimes begun with a trial deposit, lasting a few minutes. The cleaned plates are suspended in the solution, and the current adjusted to the proper strength by means of the extra resistance or subsequent change in the battery. The cathode is taken out—the circuit, exclusive of the voltameter, being kept closed in order that it may remain warm. If the small deposit is found to be firm and uniform on both sides, the plate has been properly cleaned and is in good condition to receive the regular deposit. It is then rinsed, dried and weighed as described and replaced. If the plates are large it may be necessary to put glass rods vertically between them to keep from touching each other. The circuit is closed and the time of closing noted. The needle is closely watched, and the current kept steady during the time of deposit which, as a rule, will be an hour or more. The time of opening the circuit is observed when the plates are taken out, the cathode washed and weighed as soon as it is thoroughly dried.

Large crystals on the edge indicate too great density of solution or current or both. If the deposit has a dark color there was too little acid, and the gain of weight is too large.

It is easy to obtain a uniform and solid copper deposit, and if pains be taken to keep the bath acid, to clean the plates thoroughly before deposition, and after it to wash off the solution promptly and to dry the plates well before weighing, accordant results will be obtained.

PATENTS IN THE COURTS.

BY GEORGE H. STOCKBRIDGE.

WHEN President Cleveland was making his selections of the various heads of departments and bureau officers, he was reported to have stated that he especially desired to secure an efficient Commissioner of Patents, as he had heard more complaint about the Patent Office than about any other bureau under the government. One can easily believe this report to be true in view of the severe criticisms which have been circulated of late years both in and out of the public press relative to the conduct of affairs in the Patent Office. Critics of our patent system, however, and of the manner in which it is administered, should first of all be sure of their facts. This is certainly not too much to demand, though it is more than has generally been accorded. One of the current misstatements regarding patents was touched upon in a previous article.[1] It was found that, whereas it had been charged that nine patents out of every ten are shown to be worthless under test, the facts go to prove that about seven out of every ten are judicially sustained. The figures as I gave them in my previous article made it appear that the ratio of patents sustained to those vacated is about six and a half to three and a half. I mentioned, however, the fact that the true ratio was reduced by the inclusion of reissue patents, which, since 1882, had been uniformly vacated. The reduction due to this cause is amply sufficient to make the basis of reckoning seven to three as between sustained and vacated original patents, and I shall hereafter employ that ratio as fairly indicating the facts in the case. Starting from this point, then, and before making even this showing the basis of a criticism of our patent system, as some might be inclined to do, a proper subject of inquiry still is, how far is the Patent Office responsible for the fact that not *every* patent is found to be valid when it comes to be judicially passed upon. This question will be determined most readily by considering to what tests patents are subjected. The five grounds for the setting aside of a patent are set forth in section 4,920 of the revised statutes, as follows:—

In any action for infringement the defendant may plead the general issue, and having given notice in writing to the plaintiff

1. See the *Electrical World*, New York, April 30, 1887.

or his attorney, 30 days before, may prove, on trial, any one or more of the following special matters:—

First.—That for the purpose of deceiving the public the description and specification filed by the patentee in the Patent Office was made to contain less than the whole truth relative to his invention or discovery, or more than is necessary to produce the desired effect; or,

Second.—That he had surreptitiously or unjustly obtained the patent for that which was in fact invented by another, who was using reasonable diligence in adapting or perfecting the same; or,

Third.—That it has been patented or described in some printed publication prior to his supposed invention or discovery thereof; or,

Fourth.—That he was not the original or first inventor or discoverer of any material or substantial part of the thing patented: or,

Fifth.—That it had been in public use or on sale in this country for more than two years before his application for a patent, or had been abandoned to the public.

The law provides, then, among other things (sec. 4,920, article 2), that a defendant in action for an infringement "may prove that the patentee had surreptitiously or unjustly obtained the patent for that which was in fact invented by another, who was using reasonable diligence in adapting and perfecting the same." If this is proved the patent will be declared invalid. From the nature of the case, however, it is apparent that the Patent Office has no means of knowing whether or not anyone is using reasonable diligence in adapting and perfecting an invention for which it is solicited to grant a patent. All the proof on that point is naturally brought out in the court proceedings and nowhere else. It would certainly be unfair to charge the Patent Office with responsibility for the invalidity of this class of patents.

The defendant may also prove (art. 5) that the invention "had been in public use or on sale in this country for more than two years before the patentee's application for a patent, or had been abandoned to the public." These are also matters of fact of which the Patent Office cannot reasonably be expected to be cognizant except in notorious cases. The Patent Office is not chargeable with fault, when patents are found to be invalid on the grounds just mentioned.

In the first, third and fourth articles of section 4,920, we touch upon matters for which the Patent Office may be fairly held responsible, although not wholly so as respects the fourth proof, inasmuch as the evidence showing that the patentee "was not the original and first inventor or discoverer of any material and substantial part of the thing patented" may rest upon facts of which the Patent Office could know nothing.

The first ground for the vacating of a patent is that, for the purpose of deceiving the public, the description and specification filed by the patentee in the Patent Office "was made to contain less than the whole truth relative to his invention or discovery, or more than is necessary to produce the desired effect." This is a matter which it devolves upon the Patent Office to see to. When a patentee who has taken out a U. S. patent in good faith has it declared void by the courts on either of the grounds above recited, he has a right to complain that the Patent Office has failed in its duty. It is the function of the office to see that neither the inventor nor his attorney mislead the public intentionally or inadvertently either by stating too much or too little. As a matter of fact, however, very few patents are vacated by reason of insufficient or over-sufficient specification. Practically those items can be left out of account altogether without substantially changing the result.

The great mass of vacated patents are declared invalid on the other proof above mentioned, and respecting which we have seen that the Patent Office has little or no responsibility, or upon the third proof, namely, that the invention "had been patented or described in some printed publication prior to the patentee's supposed invention or discovery thereof." Probably two-thirds of all patents vacated—that is, two patents out of every ten—are vacated on this ground. Regarding this article of the statute, the Patent Office is wholly responsible. Nevertheless, I wish to call attention to certain matters, which, while they do not excuse it, explain the fact that a large number of patents are vacated under this clause.

Take, for example, the class of electricity. Prior to July 1, 1881, there had been issued 3,875 electrical patents. Since that date electrical inventions have been patented at the rate of about 1,100 a year. By the first of July, 1889, there will have been issued in this country not far from 13,000 electrical patents. I do not know the exact number of English patents in electricity, but I suppose thay will by that time reach 7,000. For another estimate, I should say that there will be 4,000 German electrical patents and 2,000 French. Italian and other patents are not often referred to. Besides these, there are many books on electrical subjects which disclose matters not covered by patents in any country.

Now, in making searches on electrical applications, the examiners in the electrical divisions of the United States Patent Office have to search through all these various publications and that, too, with the utmost care and attention. No one who has tried it himself, with the limited time given for each examination, will wonder that two patents out of every ten are found to be broader than they ought to have been in view of references which the office overlooked.

It is not, of course, true that every time an application is examined this whole matter has to be gone over, but a dozen applications in as many different sub-classes might lead the examiners through a large portion of it. To make clear exactly what I mean, let me suppose that an inventor puts in the first day of next July an application for a patent on a dynamo-electric machine. In making his search the examiner may have to look through all the patents in the classes of "magneto-electric" "motors," and possibly "regulators," and several other sub-classes. Estimating in accordance with the number of patents in these classes down to July, 1881, and proportionately in accordance with the increase between that date and July, 1887, when the last index of electrical patents was published, the examiner will have about 1,200 United States patents to examine. If the British, French and German patents on dynamo machines and allied inventions cover the same proportionate number as do the American patents on those devices, he will also have to examine some 600 English patents, 200 French patents and 400 German. Besides, he will probably be required to examine two or three volumes devoted specifically to the dynamo machine and other volumes on general electrical subjects. If the examiner had unlimited time to devote to the subject, he would doubtless be reasonably sure, when he had ended, that nothing had been overlooked. Even then, mistakes and oversights would sometimes take place. But it must be remembered that the average time which an examiner can devote to each new application is not over half a day, though, on an invention of such importance as a dynamo-electric machine, we will give him a full day's search. Does anybody wonder that mistakes are made or, rather, does not everybody wonder that they are made so rarely?

The only foreign patent office that makes a search at all comparable to ours is the German. The German patent system, modeled after ours in nearly every particular, lays even greater stress upon the thoroughness of the search. Up to within a short time the German government printed upon the face of the patents issued under its seal a guarantee of its validity. I observe that this guarantee no longer appears on German patents; presumably because it has been found impossible to make the searches so careful and far-reaching as to leave no room for oversight. In this country, the oversights occur in two cases out of ten.

After what has been said above, it is not believed that anyone will be inclined to think me guilty of an overstatement in my former article, where I said that the statistical showing regarding sustained and vacated United States

patents is creditable to the Patent Office. Absolutely and in the abstract it may not be creditable; but it is creditable when the circumstances above recited are considered. The only way to improve the present condition of affairs is to alter the circumstances. If any administration wishes to reduce the amount of just criticism against the Patent Office, there is one way to accomplish it, and that is to do what every commissioner of patents for the last 30 years has been urging; to wit, increase the examining force and their salaries and facilities for work. No amount of executive ability in the commissioner can add authority to Patent Office examinations, so long as each examiner has to make searches on more than thirty new applications a month and keep up besides with an accumulating mass of amended work.

I am aware that some of the loudest complaints against the Patent Office are based upon the fact that the examinations are slow, a fact which is easily accounted for in view of what has been said above. Such complaints are well founded and deserve consideration; but the only criticisms, after all, which can ultimately redound to the discredit of the Patent Office are those which affect the authority of its examinations. A loss of confidence in the faithfulness and approximate reliability of the official searches would, in the end, destroy the patent system. No matter how slow the search is, within any reasonable limits, if only the proprietors of patents may feel confident that they have something upon which they can safely build. The efforts of various commissioners of patents to increase the rapidity of examinations have invariably resulted in cheapening the quality of the office work. What is needed is a force large enough to give a reasonable time to each search and skilled enough to know its business, and with room enough to do its work to advantage, and, until that is provided, it will be useless to expect a better showing for patents in the court records. More men, salaries high enough to keep the good ones, and room for them to work, will go far toward solving the problem

PHYSICS-TEACHING.

REPORT OF THE COMMITTEE, OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, ON PHYSICS-TEACHING.

Presented to the Council of the A. A. A. S., at the Cleveland meeting, August, 1888.

At the Philadelphia meeting of the association in 1884 the undersigned were appointed a committee to consider and report upon the subject of physics-teaching.

Brief reports of progress were made at the various meetings since that date, but it is only within the past year that the committee has been able to formulate and agree upon a final report which it now offers to the association through the council, at the same time respectfully requesting that it be discharged.

Before entering upon the consideration of the report, it seems proper to refer to some of the causes which have led to so long a delay in its preparation. Shortly after the appointment of your committee, consultation and correspondence with persons interested in the subject developed the great desirability of securing, if possible, the coöperation of the National Educational Association, many of the members of which were more deeply interested, if possible, in certain phases of the subject to be considered, than the members of our own body. In accordance with this idea the council of that association, at its meeting in 1885, appointed a committee on physics-teaching, consisting of Charles K. Wead, LeRoy C. Cooley, W. LeConte Stevens, W. F. Bradbury and James H. Baker.

This committee was not appointed for the specific purpose of coöperating with that of the A. A. A. S. in the preparation of a joint report, but an effort was made by the respective chairmen to secure a joint meeting of the two committees for this purpose.

This effort failed on account of the wide geographical distribution of the members. The committee of the National Educational Association prepared its report, however, and it was presented at the meeting of that body in 1887. It is probably well known to those who have especially interested themselves in this matter. An attempt was made to secure a meeting of your committee at Buffalo during the meeting of the association in that city in 1886. A majority of the committee was present and an informal discussion of the subject was had, but it was thought best to defer any report until a full meeting could be held.

Accordingly a meeting was called at Washington, D. C., in December, 1887, and at this meeting, the first session of which was on December 24, all of the members of the committee were present except Professor Trowbridge, who found it impossible to attend.

At this meeting the subject was fully discussed and it was found that the members present were substantially in agreement as to the principal questions involved.

In presenting the conclusions reached it is not thought to be necessary or desirable to insist upon the importance of the study of physics or to offer arguments in favor of its introduction. This ground has been gone over so often and so thoroughly within the past decade that further discussion seems unnecessary.

As a matter of fact it may be said that nearly everything which can be justly claimed is now nearly everywhere admitted. Neither has it been thought necessary to go into detail as to methods of instruction.

The publication in the English language within a few years, of several excellent text-books of physics and a few laboratory guides of a high order of merit, together with a considerable advance in real scholarship among teachers, make it possible to use the phrases "text-book work," "lecture work" and "laboratory practice" with a fair chance of being understood; yet it may be well to remark that where the latter is referred to, something very different from mere illustrative experimentation is meant, it being the opinion of the committee that the work in the laboratory should be quantitative rather than qualitative, and always of as high a degree of precision as is possible with the appliances available.

In order to give definiteness to its conclusions the committee undertook to answer the following questions:—

1. In what grade of the public school should physics-teaching begin?

2. What should be the character of this first instruction? oral? By text-book? By laboratory methods? etc.

3. What should be the character of the physics-teaching in the high school? Text-book? Laboratory? Text-book followed by laboratory? Laboratory followed by text-book? or, Laboratory and text-book combined?

4. What knowledge of physics should be required for admission to college?

5. What should be the minimum course in physics for under-graduate students, and what should be the nature of this course?

In answering these questions the needs of special students, or the requirements of scientific and technical schools and courses have not been considered. It may be fairly assumed that such students and courses and schools will take care of themselves.

The conclusions reached have reference only to the minimum training allowable in a course of study so adjusted as to give the student what we may continue to call, for want of a better name, "a liberal education."

1. In answer to the first question, it is the opinion of the committee that instruction in physics may begin, with profit, in what is generally known as the "grammar school." At the same time it is decidedly opposed to any general recommendation that it must begin there or in the primary school. Here, perhaps more than anywhere else, nearly everything depends on the teacher. One who has

a strong liking for and a good knowledge of physics will be tolerably certain to succeed, while another not thus equipped for the work is equally certain to fail. Teachers belonging to the first class constitute an extremely small percentage of the grand total. In science-teaching in grades below the high school, much should be left to the individuality of the teacher. As a result of personal taste or previous training and study, one may give elementary instruction in botany, or in geology or in physiology so as to be a real inspiration to his class, while his instruction in physics might be so intolerably poor as to be unprofitable in the highest degree. The prevailing custom of many public schools which requires all teachers of a certain grade to teach physics is greatly to be regretted, and every effort should be made to show school superintendents that it is a mistake which cannot be too quickly remedied.

The rapid advancement which is constantly being made in real scholarship among public school teachers will result in an increased and increasing number of those who are competent to teach physics; and while the committee is convinced that, as a means of real, honest, mental discipline, no branch of natural science is superior to physics, it would deprecate its forced introduction into the grammar school under circumstances likely to prove disastrous to the best interests of the science.

2. When taught in the grammar school, and by a competent teacher, it should be done mainly by and through illustrative experiments.

These may be of the simplest character, involving and exhibiting some of the fundamental principles of the science, and they should generally be made by the teacher, the pupil being encouraged to repeat, to vary and to extend. Habits of observation and of thought should be cultivated, and such facts of the science as are based on or relate to the principles illustrated and developed should be presented. It is neither desirable nor necessary that any particular order should be followed in presenting the various divisions of the subject. The teacher should be guided by circumstances, such as the means at his disposal for experiment and illustration, and often by his own taste and predilection.

The ease with which apparatus for the illustration of the most important principles of physics can be improvised, even when the stock of materials at hand is very slender, puts the science in the front rank as to availability, and it is especially adapted to the requirements of certain schools both in town and country which, through their situation and surroundings, are restricted in their choice of a science subject. If to these facts we add another, which is universally admitted, that the physical properties of matter are the first to be recognized, the laws relating to which being, therefore, the first to arrest attention, it needs no argument to show that a competent instructor will find the study of physics one of the most important educational forces, even in the grammar school.

3. In any discussion of the character of instruction in physics in the high school, one fact of the utmost importance must not be lost sight of. It is that a large majority of the young people who are educated in the public schools receive their final scholastic training in the high school.

Its course of study must be in harmony with this fact, such provision as may be made for those who continue their studies in college or university, being merely incidental.

The high school course in physics must include therefore a general treatment, which must of necessity be elementary in its character, of all the great divisions of the science.

It is likewise important that the student should be made acquainted, if only to a limited extent, with the methods of physical investigation and that he should be able himself to plan and carry out an attack upon some of the simpler problems of the science. The value of this work as an educational factor cannot be overestimated; it is the "walking alone" of intellectual infancy.

It is believed that these two very desirable ends can be reached without giving an undue share of the time and energy of the pupil to the subject. Assuming the high school course to consist of four years of three terms each, it is recommended that the study of physics should begin not earlier than with the third year; that it should continue through one year, three hours a week being devoted to it, not including the time necessary for the preparation of the lesson; and that during the first two terms the work should be text-book work, accompanied by illustrative experiments performed by the instructor and made as complete as his facilities will allow, while the last term should be devoted to simple laboratory exercises. It is hardly necessary to say that during the last term the three hours per week should be grouped into one exercise whenever possible.

Of the character of this laboratory practice it may be well to say that no attempt should be made to carry the pupil through a very great range of subjects. The end sought for can best be reached by a careful and more exhaustive study of a few problems which should be solved with the highest degree of accuracy attainable under the circumstances. As far as possible the pupil should be led to read and study books and papers bearing upon the particular subject which he has in hand. The time demanded by this plan, three hours per week for one school year, barely more than a hundred hours in all, is thought to be the least which is likely to produce results at all satisfactory, and it is urged that a vastly better arrangement is to allow the study of physics to run through two school years, giving it in time, the equivalent of five hours per week for one year.

It is well known that many teachers of physics, and many more who are not teachers of physics, insist on the introduction of laboratory practice from the beginning, some even going so far as to claim that the use of the text-book may be entirely dispensed with. Without desiring to enter into a discussion of this question, we wish to express and with emphasis, our belief that laboratory practice is in general of little real use to the student unless he comes to it fairly well grounded in the fundamental principles of the science. The somewhat widespread opinion and practice, to the contrary, will be found, it is thought, to be one of those mistakes in which pedagogics seems to be caught on the rebound from other and generally more serious errors.

4. As to the requirements in physics for admission to college, it is sufficient to say that the course indicated above should be required for admission to any and all courses in the college.

5. In reference to the minimum course in physics for under-graduate students in the college, it seems important to avoid the mistake of asking too much.

In many institutions, and especially where the elective system largely prevails, it is possible at present for students to receive a degree and yet be almost absolutely ignorant of the principles of physics. It is the judgment of the committee that a knowledge of this subject constitutes one of the necessary and essential elements of a liberal education, and a minimum course of three hours per week for one year is recommended. What is usually known as the junior year is most desirable for this work, as at that time the student is sufficiently mature and has acquired the necessary training in mathematics to enable him to make the best of what he does. It is recommended that this course consist entirely of text-book and recitation work, with lectures fully and completely illustrated on the professor's table.

It may possibly excite surprise that laboratory practice is omitted, but it will be remembered that this is a minimum course, in which it is not believed that the laboratory can be made to play a useful part. Whenever it is possible to increase the time devoted to the subject, this course may be and will be followed by a series of laboratory

exercises. The nature of these must depend almost entirely on the skill and judgment of the professor in charge and on the facilities which he is able to command.

In any event it should be his aim to attend rather to quality than to quantity of work, and it should not be considered necessary for each student to work in or even to touch *all* of the great divisions of the subject.

In conclusion, your committee believes that whenever the association speaks and in whatever it may say upon a subject so important as that under consideration, it should be governed by a wise conservatism, and that it should keep always in view the fact that when its suggestions and recommendations are in the real interests of the school and the college they are certain to be in the line of the advancement of science.

T. C. MENDENHALL, *Chairman.*
WM. A. ANTHONY.
H. S. CARHART.
F. H. SMITH.

Salem Press, July, 1888.

PRACTICAL NOTES CONCERNING THE CONSTRUCTION, USE AND MANAGEMENT OF STORAGE BATTERIES.

BY A. RECKENZAUN.

(Continued from page 394, vol. vi.)

PROPELLING ELECTRIC LAUNCHES.

MUCH has been written and said about the adaptability of storage batteries to purposes of marine propulsion; nevertheless the question of weight of the battery is continually being reopened by persons interested in the subject. The hopes which were entertained a few years ago, and which still fondly cling to the breast of amateurs, that "some day" we shall have storage batteries of very light weight compared with great power, are gradually being dispelled. Structurally, secondary batteries have been much improved since the first electric launch made its appearance; but the attempts to reduce weight have failed, and it is admitted by all who give the subject serious consideration that the present most successful combinations have been determined after much practice, from which it is difficult to deviate without sacrificing some essential quality. For special purposes, where first cost and depreciation do not enter into calculations, we may yet wring a morsel from the possibilities which nature provides.

Theoretically, a comparatively large amount of energy is manifested in the separation of metallic lead from its oxide. According to Professor Reynolds, it equals 360,000 foot pounds per pound of lead acted upon, if every atom could be brought under the influence of chemical action. But in secondary batteries we cannot use the material in such a finely divided state; we require a support, which must also be a conductor, and this, with the acid and a suitable receptacle, brings the weight up to over 10 times the value given in chemical equivalents. Several years practical experience point to the conclusion that secondary batteries of sufficient mechanical strength and durability cannot yield much more than seven watt-hours per pound weight of material. This includes plates made of lead and oxides of lead, acid, cell and terminals; and these figures are based on the assumption that the rate of discharge does not exceed three-quarters of an ampere per pound of accumulator, or, approximately, one ampere per pound of plate. At this rate it is possible to maintain an average E. M. F. of at least 1.87 volts per cell for the entire useful discharge period.

A pleasure launch of 30 feet length, 6 feet beam and 2 feet draught of water can be driven at a speed of from six to seven miles an hour in still water, with an expenditure of about 3,000 watts, through an efficient motor actuating an efficient screw propeller. A continuous run for six hours would thus necessitate a battery of 2,571 pounds weight, consisting of 60 cells, if each were to weigh 43 pounds.

Seven miles an hour may be considered a moderate speed. It is, of course, possible to travel much faster than this, but at an enormous sacrifice of energy. Each additional mile involves an increase of power altogether out of proportion to the gain in speed. To illustrate this we may cite an example from carefully conducted speed trials on the measured mile at Long Reach, in April, 1886, under the auspices of Messrs. Yarrow & Co. and the naval attachés of the Italian government. The launch in question was built of steel on the most approved lines; it was 36 feet long and of 6 feet beam; her storage battery consisted of 73 cells. With 53 cells in circuit an average speed of 7.51 miles per hour was attained, and when 20 extra cells were switched into circuit the average speed came to 8.43 miles per hour, showing an increase of only .92 of a mile per hour with 37.7 per cent. more E. M. F. Theoretically, the power required to drive a boat varies as the cube of the speed. Great speed, therefore, can only be obtained with a high current rate, which means a very rapid discharge of the cells and a correspondingly early destruction of the plates. There is scarcely any advantage gained by increasing the size of the battery if the same is already as heavy or heavier than the hull and live load combined; consequently the limit of speed in any electric launch has to be determined by the limit of the current which the accumulator is capable of giving off at any time.

With regard to the space occupied by a lead battery yielding seven watt-hours per pound weight, this we find to be about one cubic foot per 1,000 watt-hours. The cells in the 30 feet boat above referred to, with a capacity of 3,000 watts for six hours would then occupy 18 cubic feet, or if the height of the boxes over all is 1 foot, the necessary floor space must be 18 square feet. Confining ourselves to small vessels, which come under the category of "launches," driven by lead storage batteries, we may safely assert that these can never be propelled at a speed of more than 15 miles an hour, no matter what sacrifice we make; furthermore, it may be stated with equal certainty that the distance that can be traversed with one charge of batteries in still water will not be more than 100 miles, at a speed of not less than four miles an hour. Within these limits, however, there is a fruitful field for further developments, and the steps taken by Messrs. Immisch in establishing charging stations up the river are likely to cause a demand for boats propelled by electric energy.

EFFECT OF SHAPE OF PROPELLER UPON RATE OF DISCHARGE.

One of the most difficult parts of a launch is the screw propeller. Almost any kind of screw will push a vessel through water, but with different samples results of a varying kind may be obtained. In order to ascertain the merits of some, we made a series of experiments, five years ago, with three screw propellers on a small launch. It will be observed that in each experiment there were considerable differences in the current and number of revolutions, although the same battery and motor were used in every case. Each screw had only two blades; the dimensions were as follows, distinguishing them by the letters A, B and C:—

	A	B	C
Diameter in inches	19.875	18.75	17.75
Mean pitch in inches	12.9	12.25	11.5
Disc area of blades, square inches	94	76	59
Whole disc area, square inches	314	276	247
Expanded area of blades, sq. inches	103	82	66

Table xi. gives the mean results of the tests with each screw, and it shows that the work done does not vary in proportion to the energy expended upon it. The relative

work of the screw is assumed as proportional to the number of revolutions, and the relative energy consumed varies with the current.

TABLE XI.

Number of experiment.	Revolutions per minute.	Relative work of screw.	Current in amperes.	No. of cells.	Electrical horse-power.	Relative electric energy.
			A			
1	599	1.00	48.8	40	5.76	1.00
2	630	1.05	57.2	45	7.6	1.30
3	830	1.38	63.5	50	9.36	1.62
			B			
4	684	1.00	40	40	4.71	1.00
5	748	1.09	46	45	6.1	1.29
6	880	1.28	52	50	7.66	1.62
			C			
7	738	1.00	29	36	3.07	1.00
8	786	1.06	30	41	4.35	1.41
9	840	1.13	43	46	5.6	1.82

(To be continued.)

ELECTROLYSIS OF TIN SALTS.[1]

BY ALEXANDER WATT.

ALTHOUGH there have been many attempts to introduce electro-tinning as a branch of the electro-plating industry, the art has not yet attained a high state of development, at least in this country. That electro-tinning is susceptible of many useful applications is beyond doubt, but it is also true that no really good electrolyte has yet been discovered which will enable the depositor to pursue the art with the same facility and comparative certainty with which he can generally conduct the deposition of other metals which receive his daily attention, as gold, silver and nickel, for example. Of the several causes which affect the uniform action of the tinning baths ordinarily applied, the most important are:— 1. That the anode does not dissolve with sufficient rapidity to keep up the normal strength of the solution, which necessitates the frequent addition of tin salt to the electrolyte; consequently the liquid is never in such an uniform condition as to ensure regularity of deposit. 2. That the tin solutions usually employed, being constantly under atmospheric influence, are continually undergoing change of condition, and as a consequence are unreliable. These are serious faults in any electrolyte to be employed for commercial purposes on a large scale, and place the operator at a continual disadvantage, since he can never know to a certainty when his bath may require an addition of tin salt, nor the precise quantity necessary to keep the bath at its normal strength.

Many different salts of tin have from time to time been employed for making up baths for the electro-deposition of the metal for practical purposes, but it is doubtful whether the chemical field has been sufficiently explored to render improvement improbable. With this impression, I carried out a long series of experiments, the results of which will, it is hoped, prove useful to those who may desire to know the behavior of other salts of tin than such as are usually employed for the deposition of the metal, while it is possible that the results I am about to describe may suggest further modifications in the minds of others, and thus tend to the ultimate development of a really good tinning bath, free from the defects to which attention has been called. In conducting the following experiments the Daniell battery was employed, and in most instances the current from a single cell, or about .669 ampere, was found sufficient for the deposition of the metal from most of the electrolytes employed The anode consisted of a stout plate of tin, about three inches square, and the receiving plates were generally strips of sheet brass, three inches long and one inch wide, to each of which a length of copper wire was soldered. Before commencing the various trials, a quantity of the hydrates of protoxide and peroxide of tin was prepared, and after being well washed and drained, the respective oxides were kept in their moist condition for the preparation of tin salts as required.

1. *Protochloride of Tin.*—It is well known that a solution of this salt, when subjected to electrolytic action, deposits metallic tin either in a spongy condition or in the form of crystals, according to the strength or weakness of the electrolyte and the amount of free acid present. When electrolyzing a solution of the protochloride it has frequently been noticed, after the electrodes have been immersed in the bath for a few moments, that bright crystals of metallic tin of a feather like appearance would form upon the surface of the cathode, and eventually spread forwards until they reached the anode, when the current would be short-circuited and the crystals would then drop from the cathode and deposit at the bottom of the vessel. Being anxious to obtain permanent specimens of the beautiful crystals produced from the protochloride solution by electrolysis, I proceeded in the manner described in my former papers on the "Electrolysis of Lead Salts" (*Electrical Review*, April 27th, 1888). A solution was first prepared by dissolving 120 grains of fused protochloride of tin in 16 ounces of water, acidulated with half an ounce of hydrochloric acid. This solution was then filtered and afterwards poured into a flat dish,

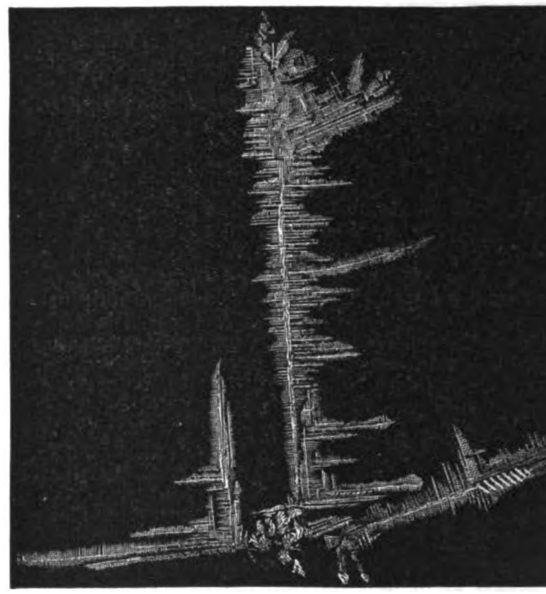


FIG. 1.

on which was laid a plate of glass about seven inches by five inches. A tin anode, connected to the positive pole of a single Daniell cell, was then immersed in the bath and allowed to rest on one end of the glass plate; a narrow strip of sheet brass, slightly curved at its lower end, and with copper wire attached, was used as a cathode, and this being connected to the negative electrode of the battery was next placed upright on the opposite end of the glass plate, when in less than half a minute small fern-like crystals began to form at each corner of the cathode, and gradually extended, radiating in all directions, but chiefly in the direction of the anode, until in the course of about half an hour

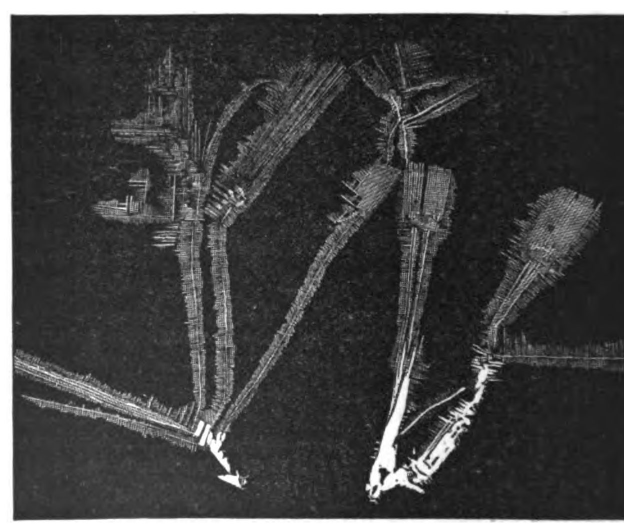


FIG. 2.

they had attained the length of several inches, the crystals lying perfectly flat upon the surface of the glass plate, like seaweed expanded in water, excepting those in immediate contact with the cathode, which accumulated in clusters reaching to the surface of the liquid, which latter covered the plate to the depth of about one-eighth of an inch. In little more than an hour the plate was nearly covered with crystals of most exquisite beauty, but in separate groups, proceeding from the extreme corners of the cathode. It was noticed that as the crystals grew nearer to the

1. From the *Telegraphic Journal and Electrical Review* (London).

anode they extended with greatly increased rapidity; so much so, indeed, as to create some little astonishment, while this rapidity of formation caused the crystalline deposit to become highly attenuated at the extreme points nearest the anode. When the crystals had approached within $\frac{1}{16}$th of an inch of the anode, that electrode was withdrawn, and the crystals then carefully disconnected from the cathode with the blade of a penknife, and the brass plate then removed from the liquid. The solution was then

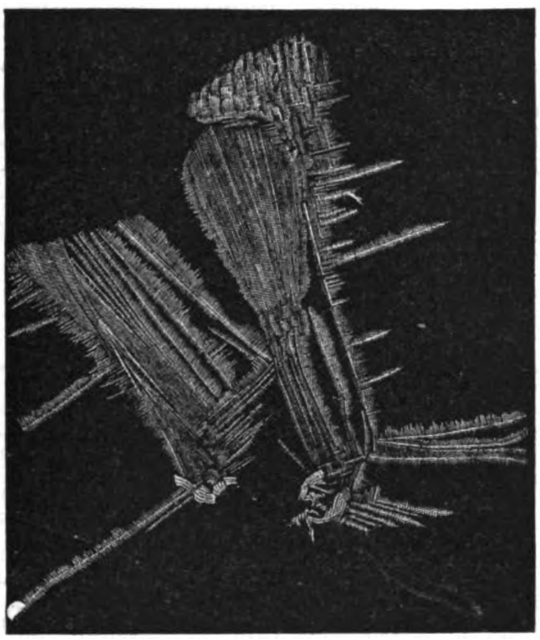


FIG. 8.

carefully and slowly poured out of the dish, and the glass plate bearing the crystals then removed and placed in a nearly upright position upon a pad of blotting paper to drain, after which it was replaced in the dish (which had been previously well rinsed) and water slowly poured in until the plate was well covered, the object being to wash away the adherent tin salt. Portions of the washing water were from time to time withdrawn by means of a pipette, and fresh water applied as before, until the crystals were fairly cleansed from the salt of tin. It should be mentioned that the water used in washing the plate produces a white precipitate, which it is necessary to prevent from settling on the surface of the plate, and this can be effected by the method indicated, but the greatest care is necessary to prevent the fragile deposit from becoming disturbed, in which case it would inevitably float away from the surface of the plate. Instead of pouring off the tin solution when the crystals are obtained, I find it a better plan to gently raise the glass plate at one end with the first finger and thumb of each hand, and finally rest it on one corner until the greater portion of the liquid has drained from it into the dish; it is then placed on a pad of blotting paper as before mentioned. It is important to bear in mind that if the tin salt surrounding the crystals is not removed by washing, the delicate crystals are apt to become partially redissolved, while the salt will also crystallize in drying, and thus destroy the beauty of the result. When the plate has been sufficiently washed, it is gently removed from the dish and drained as before, and may then be put in a warm place or held before the fire until dry. It should next be coated with a thin varnish—ordinary photographic varnish is most suitable—which should be applied by pouring it in the centre of the plate, and allowing it to flow towards each corner, finally tilting the glass to allow the surplus varnish to return to the bottle. Before and after applying the varnish, the plate should be slightly warmed by holding it at a short distance from the fire.

Having now protected the tin crystals by a coating of varnish, we may next proceed to obtain reproductions or prints from them in the same way as ordinary photographic pictures are obtained, by treating the glass plate bearing the crystals in all respects as a photographic "negative." The plate being placed in a suitable printing frame, with the crystals upward, a piece of sensitized albumenized paper is laid on the face of the plate, and over this several folds of blotting paper. The shutter of the frame is then adjusted in the usual manner, and the frame exposed to the action of sunlight until all the details of the crystals are fully impressed upon the sensitized paper. The print is then withdrawn, and it is afterwards fixed, toned and washed in the usual way, and after being allowed to dry, may be mounted on a suitable card. In the accompanying illustrations several examples are shown of impressions, taken by the photographic method, of tin crystals produced with solutions of the protosalt of tin at various degrees of concentration, and it will be observed how greatly the forms of the crystals are modified by increasing or diminishing the metallic strength of the tin bath, and also by changing the form of the cathode. In figure 1 the crystals were produced in a solution containing 7½ grains of fused chloride to each ounce of water, moderately acidulated with hydochloric acid, the cathode employed being stout copper wire of about one-fourth inch thickness. Figure 2 represents crystals obtained in the same bath, with a brass cathode about one-half inch wide. In figure 3 the crystals were obtained in the above solution, with a cathode turned up into a semi-circular form, the corners facing the anode.

(*To be continued.*)

THE MINIMUM POINT OF CHANGE OF POTENTIAL OF A VOLTAIC COUPLE.[1]

BY DR. G. GORE, F.R.S.

IN this communication is described the following very simple method of detecting the influence of the minimum proportion of chlorine or other soluble substance, etc., upon the electromotive force of a voltaic couple (*Nature*, vol. xxviii, p. 117).

Take a voltaic couple, composed of an unamalgamated strip of zinc or magnesium (the latter is usually the most sensitive), and a small sheet of platinum, immersed in distilled water, balance its electric potential through an ordinary galvanometer of about 100 ohms resistance by that of a precisely similar couple, composed of portions of the same specimens of the same metals, immersed the same moment as the other pair in a separate quantity of the same water, and gradually add to one of the two cells sufficiently small and known quantities of an adequately weak solution of known strength in a portion of the same water, of the substance to be used, until the balance is upset, and take note of the proportions of the substance and of the water then contained in that cell. In the present experiment a magnesium-platinum couple was employed.

The minimum proportions required with several substances were as follows:—potassic chloride, between 1 part in 3875 and 4650 parts of water; potassic chlorate, between 1 in 4650 and 5166; hydrochloric acid, between 1 in 516,666 and 664,285; and with chlorine between 1 in 15,656,500,000 and 19,565,210,000.

The proportion required of each different substance is dependent upon very simple conditions, viz., unchanged composition of the voltaic couple, a uniform temperature, and employing the same galvanometer. The apparently constant numbers thus obtained may probably be used as tests of the purity or of the uniformity of composition of dissolved substances.

The "minimum point" varies with—1st, the chemical composition of the liquid; 2d, the kind of positive metal; 3d, to a less degree with the kind of the negative metal; 4th, the temperature at the surface of the positive metal, and at that of the negative one; and 5th, with the kind of galvanometer employed.

The order of the degree of sensitiveness is manifestly related to that of the degree of free chemical energy of the liquid, also to the atomic and molecular weights of the dissolved substances, and to the ordinary chemical groups of halogens. The greater the degree of free chemical energy of the dissolved substance and the greater its action upon the positive metal, the smaller the proportion of it required to change the potential.

As the "minimum point" of a chemically active substance dissolved in water is usually much altered by adding almost any soluble substance to the mixture, measurements of that point in a number of liquids at a given temperature with the same voltaic pair and galvanometer will probably throw some light upon the degree of chemical freedom of substances dissolved in water.

POINTERS.

.... MAN is an animal in body, stomach, and legs; but then he is an animal with opinion, and forever he has been systematizing these opinions into philosophies. In the early philosophy everything was endowed with life—and deified—stones, trees, fountains, forests, beasts, winds, waves and stars; and the mysteries of the universe was explained by making all these things intelligent actors. From this, the earliest philosophy of the lowest savage, it is a long way to the philosophy of science, and there have been many stages.—*Major J. W. Powell.*

.... IT seems odd that a judge who decides that the conversion of high into low tension currents and *vice versa* by means of induction coils was common knowledge at the time of Gaulard and Gibbs' patent should decide that there is any invention in the method of connecting up these apparatus in series and that those who employ them in parallel do not infringe. The coupling up of any or *all* electrical apparatus, whether in series or parallel, was common knowledge many years before Gaulard and Gibbs or Zipernowski-Deri were ever heard of.—*Foreign paper.*

1. Read before the Royal Society, June 14, 1888. Abstract.

PAPERS READ BEFORE THE NATIONAL TELEPHONE ASSOCIATION, NEW YORK, SEPTEMBER 4 AND 5, 1888.

NOTES ON TELEPHONE BATTERIES.

BY F. A. PICKERNELL.

I SHALL not attempt, in these notes, to recommend or describe any particular battery, but shall content myself with pointing out defects existing in the batteries now commonly used for transmitters, and emphasizing the importance of certain features which all telephone batteries ought to possess.

The selection of batteries for transmitters has always been a matter of considerable importance, although not always recognized as such. When the battery transmitter was first introduced, nearly all telephone wires ran on overhead structures, no cables being used. The retardation in these circuits was consequently slight, and it was during this period of the business that the large margin in transmission was observed, it having been found possible to talk with the same ease over circuits fifty miles long as it had previously been over circuits a mile long. This led naturally to poor construction, lines being built with small gauge iron and steel wire, and in many cases without insulators. Such construction cut down this margin of transmission to such an extent that it was found impossible to talk over such lines in bad weather, unless the transmitter and battery were in the very best condition.

Better construction followed, and with better construction the battery problem was of less importance. More recently, however, the extensive introduction of cables has again cut down the margin of transmission. This of course renders it necessary to keep the transmitter and its battery in better condition. As the cable system of any telephone exchange increases, in a like ratio will the importance of the battery problem increase. It was only last week that a gentleman was telling me of his experience in confirmation of this. His company had a cable two and a half miles long which not only had a high electrostatic capacity but also a high resistance. This cable was used mainly for trunk wires. It was noticed that many subscribers who had no difficulty in talking with parties in their own exchange, had considerable difficulty in talking with parties in the other exchanges connected through this cable. Upon inspection it was found that invariably a poor battery was found at the subscriber's instrument. This cable made a very good battery inspector and one, I may say, that did not ruin the transmitter in inspecting.

The battery most commonly used for transmitters is of the Leclanché form. The little attention required by a battery of this class, its freedom from violent acids, the ease with which it is set up, its small consumption of zinc, there being no consumption when the battery is on open circuit, all unite in making it the leading form of telephone battery. However, it polarizes rapidly, and has a high and constantly increasing internal resistance when worked over a low resistance circuit, as it invariably is when used for transmitters. The importance of low battery resistance is shown clearly by the following considerations.

The efficiency of any transmitter, other things being equal, is proportional to the variation in current strength produced in its primary circuit, the greater the variation in current strength the greater being the efficiency. The variation in current strength being proportional to the variation in resistance, it follows that the efficiency of any transmitter is proportional to the variation of resistance produced in its primary circuit. The following table, calculated for a Blake transmitter, shows how important is the part battery resistance plays in modifying this variation in resistance, in other words, in modifying the efficiency of the Blake transmitter

This table assumes the variations in a Blake transmitter to be from 5 to 15 ohms, these figures being the result of many measurements.

Table for Blake transmitters. Resistance of primary circuit of induction coil .5 ohms.

Battery resistance.	Minimum resistance.	Maximum resistance.	Ratio of min. to max.	Percent'ge decrease of ratio from that of battery of no resistance.
.0	5.50	15.50	1:2.82	
.33	5.83	15.83	1:2.72	3.5
.67	6.17	16.17	1:2.62	7.1
1.00	6.50	16.50	1:2.54	9.9
1.33	6.83	16.83	1:2.46	12.8
1.67	7.17	17.17	1:2.39	15.2
2.00	7.50	17.50	1:2.33	17.4

Two ohms is not an uncommonly high resistance for Leclanché batteries, and from the table we see that the variation from its minimum resistance to the maximum resistance of the primary circuit of a Blake transmitter decreases from a ratio of 1:2.72 in the case of a battery of .33 ohms internal resistance to a ratio of 1:2.33 in the case of a battery of 2 ohms resistance, a decrease of 14 per cent.

With long-distance transmitters the battery resistance is an even more important factor, as will be seen by the following table. This calculation for long-distance transmitter assumes variation in resistance to be from 4 ohms to 20 ohms; resistance of primary of induction coil .45 ohms. Three cells of Leclanché batteries are generally used with this transmitter.

Battery resistance.	Minimum resistance.	Maximum resistance.	Ratio of min. to max.	Percent'ge decrease of ratio from that of battery of no resistance.
.0	4.45	20.45	1:4.60	
.33	5.45	21.45	1:3.94	14.
.67	6.45	22.45	1:3.48	24.
1.00	7.45	23.45	1:3.15	32.
1.33	8.45	24.45	1:2.89	37.
1.67	9.45	25.45	1:2.69	42.
2.00	10.45	26.45	1:2.53	45.

From this table we find that the variation is decreased from 1:3.94 when batteries having internal resistance of .33 ohms are used to a ratio of 1:2.53, when batteries of 2 ohms internal resistance are used.

These tables likewise show why it is that even a slightly defective joint in the primary circuit prevents the action of the transmitter.

Polarization is a defect of even more importance than internal resistance. It is not uncommon for a Leclanché battery to decrease 30 per cent. in E. M. F. after ten minutes' use. This of course decreases the average current in the primary circuit of the transmitter in a like ratio.

Having noticed now the importance of low and constant internal resistance and constant E. M. F., I will next call attention to some of the causes which operate to render telephone batteries not only poor to start with but unreliable in service. Lack of porosity in the porous cups is frequently the cause of high battery resistance.

Commonly, porous cups are found which contain peroxide of manganese dust. This dust should never be admitted, as it invariably increases internal resistance. The peroxide should be in particles about the size of small peas. Binding posts are frequently found which do not make good connections with the electrodes. The binding post on the carbon plate is often found after a few months' use to be almost entirely insulated from the plate. This is caused by the salts creeping up through the carbon, and corroding the metal binding post. The upper portion of the carbon is supposed to be entirely impregnated with paraffine to prevent this crawling, but very often the carbon is not soaked long enough to become thoroughly saturated. Care must be taken not to use an excess of sal-ammoniac in setting the battery up, for otherwise crystals will form on the zinc, increasing very much the internal resistance. If the sal-ammoniac becomes impoverished a complicated chloride of zinc will deposit in the same manner. A poor quality of the peroxide of manganese is frequently found in porous cups. When such is used polarization takes place very quickly.

Gravity batteries and bichromate of potash batteries have been used to a considerable extent, especially for long-distance transmitters. These batteries require much more attention than the Leclanché battery, and are not so reliable. The battery, which, in its electrical properties, approaches more nearly the ideal battery, is the storage battery. This combines constant E. M. F. with very low internal resistance. Two cells of storage battery on a long-distance transmitter give the very best transmission. This form of battery cannot, of course, be generally used on subscribers' instruments.

Many modifications of the Leclanché battery have recently been introduced, some having remarkably low resistance; but they all polarize more quickly than is desirable. I think that if we have not already a modified Leclanché battery that combines low resistance with constant E. M. F., that we will soon have one, and this will be beyond question the telephone battery of the future. I see no reason why a battery of this kind could not be made having an internal resistance of considerably less than .5 ohm and a constant E. M. F. of 148 volts. This battery could be put up in a package with nothing but the terminals projecting, and these I may say should be provided with the best possible forms of binding posts. By using nothing but the best material, and properly designing the electrodes, polarization could to a very great extent be prevented, and by properly proportioning the components exhaustion would take place in all the parts about the same time. Such a battery would give, when set up,

the very best possible results and would require no inspection. When the battery became exhausted no unsatisfactory doctoring would be done by the inspector; he would simply replace a battery by a new one. Until some such battery is generally introduced we may expect about the same percentage of battery troubles that we are now having.

DYNAMO CURRENT INTERFERENCES WITH TELEPHONE SYSTEMS, AND MEANS OF RELIEF.

BY C. L. MC CLEUR.

DURING my earlier telegraphic experience I became imbued with the universally accepted belief in the theory that the earth was an immense reservoir of electricity, and that on that account, and because of its immense mass, it offered no appreciable resistance to the transmission of electrical force. Hence the universal use of the earth as a return conductor for telegraph and other electrical circuits, which are in consequence called "mixed circuits," in contradistinction to circuits composed wholly of metallic conductors. But my attention being called to the behavior of our telegraph apparatus under the influence of extraneous currents, I was finally led to question the correctness of the theory of the "infinite conductivity" of the earth.

Like nearly all of the early workers in the new field opened up by Professor A. Graham Bell's invention, I was also led into the error of attributing to "induction" nearly all the ills to which the telephone was heir.

Experience and observation, however, soon convinced me that nearly all the telephone troubles popularly supposed to arise from "induction" were the result of "leakage" only; induction operating only at minute distances, while leakage would occur across wide intervals. Hence I was to some extent prepared for my subsequent experiences with the effects of electric light and electric power circuits upon telephone systems, experiences which, as I will now proceed to explain, confirmed me in my disbelief in the theory of "infinite conductivity" and the effects of "dynamic induction."

Some three or four years ago, Richmond was captured by the advance guard of the army of Knights of the Dynamo, to which she is now so largely tributary, and the Schuyler Electric Light Company soon had the city ablaze with arc lights. At first we experienced little or no trouble, but after a time strange noises were heard in our exchange telephones, and as the electric light construction was extended and circuits and arc lights were multiplied, the noises increased until they finally became a din, over which it was almost impossible to project the voice. After careful consideration, I suggested certain reversals of dynamo currents, and re-arrangement of the electric light metallic circuits, which were adopted by our electric light friends, greatly to our relief. But on some of our exchange wires, notably those on our Broad street trunk line extending to the extreme western and northwestern limits of the city, the howling of the dynamo currents remained comparatively unabated. After further consideration I became convinced that the principal source of our telephone troubles was a long electric light circuit, which traversed Main street to the western limits of the city, then crossed north ward to Broad street, which it followed eastwardly to a point opposite the power house, and thence in a southerly direction to the dynamo, thus making a loop about a mile and a half in length by a quarter mile in width. One side of this loop ran parallel with our Broad street trunk line, almost the entire length, with only the width of the street between them. I was at first inclined to attribute to the usual scapegoat "induction" the interference which we experienced on our Broad street wires, but my attention being about this time directed by some of my linemen to the interesting fact which they had discovered, that even in the dryest weather enough of the dynamo current on this large loop escaped over the insulators and down the poles, to be perceptible to the tongue when applied to a pole four or five feet from the ground, while in rainy weather a very perceptible shock could be felt by applying the hand to a wet pole.

My former opinion regarding "induction" versus "leakage" and the "infinite conductivity" of the earth were recalled to me with redoubled force, and I soon settled down to the conviction that *leakage* was the force with which I had to deal. This conviction was strengthened by the well-observed fact that the interferences from the electric light currents were greatly increased during wet weather.

But the famous Richmond Union Passenger Railway, with its street cars propelled by electricity, became a moving, flashing reality in January of the present year, and for a time rendered the telephone business in Richmond decidedly interesting. Unlike the electric light and power systems, the electrical plant of the railway company was not designed or arranged for metallic circuits, but was, and still is, operated by mixed earth and metallic circuits, the currents being carried to the overhead trolley wires by a system of distributing mains, supported upon poles on one side of the street, these mains being connected at frequent intervals with the trolley wire by short lateral wires termed "feeders." As operated in Richmond, the electric railway system requires a double line of poles, one line on each side of the street for the purpose of carrying short non-electric wires, which extend across the street between each pair of poles. These are termed "supporting wires," and are designed solely to support the trolley wires at the proper height above the middle of each roadway. These supporting wires and the network of special supporting or curve wires, whose office it is to cause the trolley wires to curve parallel with the curves in the road-bed, are supposed to be insulated from the trolley and feed wires and mains; but, as we found to our cost, they were not by any means devoid of electrical currents. During the first six weeks after the inauguration of the electric road we had eight sets of telephones and one central office annunciator drop burned out by the railway currents, and about half of these accidents were due to crosses between our telephone wires and the supposed-to-be-harmless supporting wires. While these accidents demoralized our linemen and operators to some extent, they fortunately resulted in but little damage to property and none whatever to human life; and but few of our subscribers learning of them, they created no special commotion.

But the effect of the railway system upon our central office apparatus and telephones, from the very inauguration of the railway plant to the present time, has been annoying in the extreme, and exceedingly detrimental to our exchange service. Almost the first revolution of the battery of railway dynamos tripped the annunciators of our magneto lines, and rendered necessary an immediate resort to the use of special armature springs to overcome the magnetism imparted by the currents from the railway wires. Our "testing-off" galvanometers were rendered inoperative, because at first the polarity of the extraneous currents was opposed to that from our galvanometer batteries, and the galvanometer needles were deflected in a direction contrary to the position assumed when under the influence of the batteries alone; the leakage from the railway wires being sufficiently strong to overcome the current from three cells of Law or Leclanché battery.

This trouble I remedied by reversing the poles of my galvanometer batteries so they would, with the exception to be mentioned, coincide in polarity with the extraneous railway currents. And this exception, coupled with the continuous and steady nature of the extraneous currents, confirmed me in my belief that it was leakage and not induction from which we were suffering.

At the power house or dynamo rooms of the railway company, distant three or four squares from our central office, the battery of five or six dynamos which furnished the current for the car propulsion, was grounded, the negative electrodes being connected to several large sheets of copper at the bottom of a deep well upon the premises, the positive electrodes of the dynamos (coupled up, of course, in multiple arc) being connected "to air," as a telegrapher would put it, or to the distributing mains. From all of our exchange stations located in the vicinity of the dynamo rooms, within the radius of an entire block in fact, we would therefore get a negative leakage current, while from all other stations which were grounded within a square of the railway track and wires, we would obtain a positive current, thus rendering it impossible to arrange our galvanometer batteries to coincide with these leakage currents of opposite polarity.

We cannot, therefore, to-day use our galvanometers for "testing-off" the few stations located in the immediate vicinity of the dynamo rooms. Identically the same effect was produced upon our head-phone test circuits, the railway currents completely neutralizing the currents from our "test" batteries. This difficulty was also remedied by reversing the poles of the batteries.

The exchange lines most greatly affected by the railway currents we found by experience were those which were grounded nearest to the railway tracks, irrespective of the general direction of the wires or their proximity to or distance from the railway; lines that in no place approached within less than a square of the railway wires being as greatly affected as many others that ran parallel with, and in close proximity to the railway wires for long distances, but which terminated and were consequently grounded at points comparatively remote from the railway.

In like manner, lines grounded near the heavier grades and curves of the railway, where the motor men are compelled to use the maximum amount of power in order to ascend the grades or round the curves with heavily loaded cars, are more seriously affected than lines grounded near the levels. So clearly is this the case that our operators can readily tell from the character of the disturbance which they experience, when a car is ascending a grade, or when it stops or starts.

This effect of the movement of the cars you, of course, understand is due to the fact that the dynamo currents, when propelling the cars, are short-circuited from the trolley wires through the motor fields and armatures to the earth, thence spreading over every available conductor in their efforts to reach the dynamos. But the maximum disturbance is experienced when three or four cars are following each other in close file, either on a grade or level. In that case the leakage due to each car traverses the contiguous telephone wires simultaneously, producing in our telephones a composite or mixed tone, each motor having its distinctive "timbre" or tone quality, and all united fairly

making Rome—or the telephone, rather—howl, and drowning out the puny currents induced by our microphone batteries.

Learning that the railway people were utilizing the municipal gas and water mains in order to reinforce their ground connections, it occurred to me that possibly the fact of our lines being generally grounded on the gas and water pipes had much to do with our troubles. I had some of our wires removed from these systems and connected direct to the earth through made grounds, but without altering the results.

The 450 or 500 volt currents of the railway mixed circuit system do not, however, interfere as greatly with our Richmond exchange service as the 4,000 or 5,000 volt currents carried by the metallic circuits of the electric lighting systems. Did the railway service require currents of the same E. M. F. as the arc lights, the telephone would have to retire from the field—lose ground in fact—as metallic circuits would be their only salvation. What the railway currents lack in E. M. F., however, they make up in current strength, and are, therefore, more dangerous to property than the much more intense electric light currents. The latter will melt a fuse or burn out an arrester instantaneously before time is given it to enter a central office or a subscriber's station, and damage the telephone or outfit; while the less rapid but larger quantity of the railway current takes an appreciable time to melt or fuse an arrester, thus permitting it to burn out a hand-phone, an induction coil, or a bell or annunciator magnet, before the protector, of whatever kind it may be, can properly act.

In my experience the greater tension of the electric light currents renders them doubly disastrous to telephone exchange service, the voice being more completely drowned by the intense disturbance due to the electric light escape than it is by the escaping currents from the lower tension dynamos. But the fact of the electric light being in demand, particularly the arc lights, only after business hours, renders the disturbances engendered by them less noticed by subscribers generally than the weaker and less marked disturbances proceeding from the railway generators, which are continuous throughout the entire business hours of the day, when the telephone service is in constant demand. Did the arc light service continue during the hours of daylight as at night, telephone exchanges would be compelled to suspend operations or adopt the only alternative, metallic circuits, with the attendant increase in complication and expense.

Having thus discussed the effects of extraneous electric light and railway currents, let us address ourselves to a brief consideration of the remedies which we have at hand. Anti-induction devices for the elimination or exclusion of extraneous currents from telephone circuits, whether they be artificial or natural, are plentiful, but none have yet been devised that can at all compete with the old style metallic circuit.

But the metallic telephone exchange system carries with it not only a double expense for construction, maintenance and repairs, but a vast outlay and increased complication and expense for central office plant and service, there being two line wire terminals to provide for every subscriber, and necessarily four terminals to handle for every connection, instead of two, as with the single wire and earth systems.

This great increase in wires, in complication and consequent liability to derangement, and in initial cost, and subsequent expenses for operation and maintenance, almost prohibits the adoption of the ordinary metallic system. None but the wealthy, like our long-distance friends, can afford such a luxury. But there is a metallic circuit system within reach of even the poorest of the American Bell Telephone Company's lessees, a system of my own devising, and which I have found by practical tests to accomplish all that can be desired from an ordinary metallic circuit, and at but a tithe of the expense.

Recurring now to my theory that it was not "induction," but leakage, that annoyed us, and the expression of my disbelief in the infinite conductivity of the earth, it will readily be seen how, after arriving at those conclusions, I would very naturally reason thus: If our telephone troubles are due to leakage from the electric light and railways, and this leakage overflows into our wires from the earth *because* the earth offers an appreciable resistance to their passage, why cannot we adopt a metallic conductor of exceedingly low resistance, or of a conductivity approximating that of the earth, and use *it* in place of the earth as our return conductor, making it, in fact, what may be called an "artificial" earth or ground, and at the same time cutting loose from the earth entirely and gaining all the benefits of metallic circuits?

This idea I conceive to be in strict conformity with Ohm's law; and if only the relative resistance of the "artificial ground" or earth, and the line wires attached to it, were properly adjusted, we would have identically the same results achieved by the usual earth connections, and without the disadvantage of the mixed circuits. This thought revolved in my mind for some months before I could find time and opportunity to verify its truth or falsity by experiment. Besides, the device was so simple that I could scarcely conceive that it was possible that it had not already been tried and found to be impracticable by some member of the army of electricians that had been so long engaged in efforts to solve the anti-induction problem; and it was only after conferring with some of my brother telephonists, who were favorably impressed with the idea, which was novel to them, that I took the time necessary for experiment. I, however, finally connected up several telephone circuits with a common return wire of low resistance, and found that conversations could be carried on, and a magneto call-bell rung on each circuit without any mutual interference whatever, and it required a resistance of 35 ohms by galvanometer measurement to be added to the common return wire before the currents propagated in one circuit could be heard in the telephones on the other circuits. I thus concluded that there was approximately 350 ohms resistance in each circuit, due to the conducting wire, the call-bell magnets and the hand-phones and transmitters, and that the "artificial ground" wire should bear to the other side of each circuit, the direct or line wire, a resistance approximating one-tenth that of the entire circuit.

Encouraged by this experiment and anxious to do something to improve the night service of my exchange, I laid my scheme before the executive officers of my company, and was furnished with a half mile of No. 4 copper wire with which to make some practical tests. My first experiment was with our No. 19 northern call wire and its connecting lines. This was our shortest call wire, being only a third of a mile in length, and had connected with it some 18 or 20 subscribers' stations, located in close proximity to the Seventh street grade of the electric railway, an 8 or 10 per cent. grade, extending from Franklin to Grace street, one square. At the corner of Seventh and Franklin streets, the main feeder wires of the railway plant direct from the power house, two squares distant, first touched the line of the railway and divided right and left to the opposite and distant ends of the road. At this point, as might have been anticipated, on our telephone lines grounded in this vicinity we experienced the greatest interference, particularly when a heavily loaded car was ascending the hill. My "artificial ground" gave us immediate and remarkable relief from the railway leakage, and without any cross-talk whatever. I then applied a half mile of No. 6 covered copper wire, which I connected to the end of the first half mile of No. 4 wire, and extended the artificial ground wire on out to the western end of the city, intending to make my next test with one of our longest taps and our longest lines, with stations located near the most westerly extension of the long Main and Broad street electric light loop, of which I have already spoken. These lines had been almost entirely abandoned at night, our subscribers averring that they could not use their telephones at all after the electric lights were ablaze.

The worst of all was a station in a drug store, whose proprietor had long made bitter complaint that his telephones were of no service to him after dark. Yet when the change was made from the natural to the artificial ground, at this and all other stations on that call-wire tap, the relief from the electric light leakage was as instantaneous and marked as that experienced from the railway leakage on short tap No. 19. In fact such was the change wrought on these wires that it was possible to carry on a whispered conversation over lines connected to my artificial ground, that when connected to the natural earth were so noisy that even the loudest shouting could be heard only with extreme difficulty.

While cogitating over my idea in its incipiency it occurred to me that even the adoption of a *general ground wire* of high conductivity would relieve our telephone wires from the influence of these extraneous currents to a great extent. This I found from experience to be true.

When arranging for the central office end of my "artificial ground," I had made a plug switch so arranged that by the insertion or removal of a single plug I could connect the artificial ground wire to earth, or disconnect it entirely from the earth, and with one motion connect it with all of its attached wires into a "compound metallic circuit system." I could thus readily note the difference made by the use of the large copper wire as a *general ground wire*, or as a substitute for the earth. In the one case, as you understand, if I have made the matter clear to you, the large copper wire was connected to earth at only one point through the plug switch in the central office, while in the other it was disconnected from the earth entirely.

To those familiar with the details of a telephone exchange, it will be clear that some such provision for grounding or connecting artificial grounds to earth is essential, as long as any of the wires of the system remain in connection therewith, because of the necessity of connecting stations not yet changed to the artificial ground to those that have been thus changed; otherwise the one will be grounded and the other "dead open," and, consequently, inoperative. In this way I found by experiment that, when the large copper conductor was to earth at the central office and was being used simply as a general ground wire, the electric light and street railway interferences were reduced about 50 per cent., and when used wholly detached from, and wholly in place of, the earth, they were reduced the other 50 per cent., or eliminated entirely.

By thus utilizing the large conductor, *first*, as a general ground wire to carry the microphone and signaling currents to the earth at the central office, or at any other locality remote from the offending electric light or railway plant, an exchange

system can be gradually converted from a mixed metal and earth system into a compound metallic circuit system throughout, without any interference whatever with the service of the exchange, and to its manifest improvement during the time the change is being made. And when the last subscriber's line has been transferred from the natural to the artificial earth at the last station, it is only necessary to withdraw the solitary plug that still connects the system to the earth, and, presto! you have an exchange of purely and practically metallic circuits alone, with all of the advantages of the ordinary metallic circuit systems, the one series of large copper wires extending out on the various trunk lines, but all united in one at the central office, answering fully the purposes gained by the ordinary duplication of each individual wire, and necessitating no change whatever in either central office or station outfits or appliances, beyond the simple substitution of the artificial for the natural ground.

In practice it may be found that a greater proportion than one-tenth the resistance of any one circuit may safely be given to the artificial ground wire, but my experience and experiments lead me to believe that it will be far safer and more satisfactory to keep the resistance of the artificial ground to one-twentieth that of the entire circuit.

In an exchange the size of our Richmond exchange, I advocate the use for each individual trunk route of a single copper conductor, composed of a half mile each of No. 4 and No. 6 wire with No. 8 for lateral lines and the remaining distance to the farthest stations, with No. 14 to stretch from the poles into the stations. All of these wires should be of hard drawn copper with a good covering, and strung on the same poles and fixtures that carry the regular exchange wires, but insulated carefully both from them and the earth. And I should place these artificial ground wires at the lowest point on the poles, or the least distance from the sidewalk or ground, beneath all of the line wires if possible.

In this position the small amount of leakage currents that are attracted up the poles from the earth, whether from electric light, electric railway and power circuits, or earth currents, will be intercepted by the large copper wires, and by them carried to those points in the system where they will escape to earth again without any adverse influence upon telephone wires proper.

While in the absence of any direct experiments I cannot say positively that such will be the case; I believe, however, that if our long-distance friends will couple together so as to make of some eight or ten of their No. 12 or 14 copper wires practically a single low resistance conductor, they will find that this compound conductor will answer as an artificial earth or return wire for treble or quadruple the number of wires thus coupled together, while a single conductor of the same conductivity would double the capacity of their poles and the number of their metallic circuits. In like manner, I believe the same principle can be applied to telegraph and electric light or power circuits, relieving them from the disturbing and damaging influences of earth currents and atmospheric electricity, and conferring upon them all the advantages of metallic circuits without the ordinary duplication of wires.

In conclusion, allow me to say that, while I flatter myself that I am charitably disposed and ever inclined to do all that within me lies to further the interests of the telephonic fraternity and increase the efficiency and value of our telephone service, I do not think I am justified in assuming the role of public benefactor and giving my device away, even in the interests of science. Believing it to be novel, practicable and valuable, I have therefore conceived it to be my duty as well as privilege to apply for a patent, and my application is now pending, with, I trust, a good chance for a favorable decision.

ON THE ELECTRICAL RELATIONS OF TELEPHONE AND ELECTRIC LIGHT AND POWER CIRCUITS AND RAILWAYS.

BY T. D. LOCKWOOD.

THIS paper deals altogether with the disturbing effects of electric light and power currents upon telephone lines, and not at all with the dangers of imperfect construction and insulation; nor with the results and prevention of dynamo current crosses, there being sufficient in the latter branches of the subject for a separate and equally voluminous paper. It will consequently be assumed for the purposes of this paper that the important precaution of effectively insulating wires conducting heavy currents is observed, and that "undertaker's wire" is, as it ought to be, a thing of the past.

The telephone exchange business was commercially organized and established in the first months of 1878. Electric lighting as a commercial industry had its beginnings in 1878 and 1879, but did not at first take root with the same degree of rapidity which characterized the exploitation of the telephone, and not until some years thereafter did it achieve popularity.

Consequently the telephone systems obtained considerable start, and were firmly established in nearly every city and town in the country before the organization of many electric lighting systems. It was not at the outset generally known that the telephone circuits would be annoyed by the presence and proximity of parallel electric light wires; and telephone companies were thus at first most liberal in permitting the erection near their lines of foreign lines carrying heavy and widely fluctuating currents. Yet, a little thought and consideration would have laid bare this danger. We knew that the telephone current was itself of most shadowy and almost intangible character in point of strength, and that to utilize it such a super-sensitive instrument as we all know the telephone to be was actually essential. And we knew that *because* the telephone receiver was such a delicate electroscope, and so sensitive to electric motion, we had heretofore been much annoyed by mutual telephone induction, by telegraphic induction, and by miscellaneous induction. So, as I say, if we had carefully considered the matter, we might have foreseen the full extent of the electric light disturbance which is now being sustained.

But we did not foresee, and as a result of our lack of foresight indiscriminate construction has ensued; and in consequence of improper construction the business of many telephone companies has, at certain points, been directly or indirectly injured by the presence and operation of electric light wires, and an appeal to the courts has been rendered necessary.

Until within a comparatively recent period the disturbance resulting from dynamo current induction was, with an occasional and rare exception, limited to certain evening hours, and to the night, because during such portions only of the day were the lighting circuits in operation. But of late, in many places, the wires used in the night for lighting are also used during the hours of daylight for transmitting power from the dynamo to large numbers of motors which may be widely distributed; and as this utilization is certain to have in the near future an enormous expansion, we are compelled to face the prospect that even during the hours of business, telephone wires are now liable to severe disturbances. Therefore, it seems time to call a halt; we could be patient so long as we were only called upon to suffer from the "pestilence that walketh in darkness," but when we are also threatened with the "destruction that wasteth at noonday," it behooves us to have something to say about it. Super-added to the above causes, we now find that electric railways are being introduced in rapid succession, and we find to our cost that many of them are much more active than are electric lighting circuits in setting up disturbing currents in telephone lines; the disturbing current from electric railways being frequently sufficiently strong to vitalize the annunciator magnets of a telephone central station, and to actuate the drops.

Now, I have no quarrel with electric light and electric railway companies, considered as such. No man rejoices more heartily than I in the triumphs of electricity and in the tremendous spread of its usefulness. I recognize fully, moreover, that the lighting, power and transit utilizations of this mighty form of energy are fully as useful as is its function in carrying intelligence; and that these utilizations have properly become permanent institutions, and, equally with our own, public conveniences. Nevertheless we were first in the field, and although we may admire both the energy of the electric lighting current and the energy of its introducers, we must in our own defense be prepared to take the position that no newcomer has a right to construct his plant in such a way that an established business shall thereby be ruined or impaired, and that if it be absolutely necessary to erect electric light lines in close proximity to telephone lines, the construction must be of such a character as not to involve detriment to the pre-existing telephone lines.

Can electric light and power lines be constructed so as to be near telephone lines without interfering with them? Certainly they can. Consider how the disturbing currents originate: First, most arc lighting circuits can set up considerable induction on telephone lines. Second, alternating currents in main wires, whether used for arc or incandescent lighting, are intensely provocative of induction and noise in telephone circuits, the character of the disturbance being much worse than that which is produced by lighting currents of constant direction, this latter sounding in the telephones like a protracted musical note of great volume. In speaking of the above it will be understood that the detrimental action upon telephones is the same when the dynamo current is used for motors as it is when used for lighting. Third, certain classes of electric railways very seriously interfere with the operation of telephone lines, both in conversation and also by establishing thereon a current which permanently excites the annunciator magnets. The noises which are produced in telephones by dynamo current induction are so well known that it would be waste of time to describe them.

When the troublesome currents are produced by electric light or motor circuits they may usually be attributed to induction; although a certain amount of absolute leakage, doubtless, also exists. Since, however, both causes produce in telephone circuits a like effect, it will be sufficient to speak of induction only. But if we consider the action of electric railways upon telephone lines, we find that the major part of the disturbance is due to the actual transference of a portion of the electricity which actuates

the train motor to the telephone lines, by way of the rails (when these are used as return conductors), the crust of the earth itself, and the telephone line terminal ground wires.

As most of us know, the alternating current has received lately an increasing amount of the patronage of our light-producing friends; and at the present time both constant direction and alternating currents are largely used in electric lighting and power distribution circuits, the intensity of the disturbance varying with the class of current employed.

The violence of the induction, and therefore of the disturbance, depends upon the proximity and longitudinal distance of parallelism of the disturbing wire, the strength of the inducing current, the frequency or rate of change per time unit of the inducing currents, and the extent or range of such change. That which is due to wires carrying alternating currents is, of course, much stronger than even the worst case of direct current induction, for even though the distance of exposure and the strength of the inducing currents be identical, it is self-evident that a current which is completely reversed a great number of times per second, must be much more energetic as a disturber of the peace than one which is constant in direction, and which varies only in strength on one side of the zero line. These considerations indicate that our methods of prevention or cure should be directed at the stronger disturbing agency, since such a degree of success as we may be able to achieve against that will necessarily be equally effective as regards the weaker.

The proper way to cure or neutralize electric light or power induction *is to prevent it*. It is quite within the bounds of good construction so to relatively arrange lighting and telephone circuits that no disturbance will result; and it is obviously much easier and less costly to construct them properly in the first place than it is to change them. To secure this most desirable result, viz., the harmonious co-existence of these widely differing classes of electric service, I wish to point out that co-operation between the parties concerned is absolutely essential, together with a clear and full understanding of the conditions involved. Yet in too many instances, though, as I have stated, where the telephone wires were already in the occupancy of the field, telephone companies have negligently omitted to watch their own interests with sufficient care, and have, without remonstrance, permitted electric light companies to erect wires close to their own, and of such a character as to render inductive disturbance a foregone conclusion. Would not a general good understanding between the different electrical interests of any city or town be desirable for the forestalling of such chances of future disagreement? Informal discussion, amicable conference and mutual consideration between the authorities of the several interests would tend to preclude any possible future misunderstanding, and would certainly act to prevent unnecessary antagonisms either between any of the several individual interests or with municipal authorities. A good understanding all round is therefore suggested, as being an admirable forerunner to a system of non-conflicting construction.

Local managers of telephone companies should be instructed to report to headquarters at once, the intended construction of either electric light or railway circuits at any point within their territory, so that proper measures can be concerted, and adopted to meet the special conditions of the case. If the general satisfactory understanding, which I have outlined, can be reached, it should not, I conceive, be difficult to bring intending electric light and railway officials to see that construction which is innocuous to their neighbors, and which, in virtue of the provisions necessary to secure such innocuousness is thereby made safe in all respects, is (all things considered) both cheaper and better than construction which is at any time liable to involve them in trouble, misunderstanding and damages.

The element of distance is of the highest importance. Telephone and electric light wires cannot be too far separated for the efficient working of the former; and the wires last strung should be run, if possible, on the other streets from those in which wires are already in operation. In no case ought the two classes of circuits be nearer together than the width of an average street. In writing the above, I have not forgotten that it is oftentimes a matter of mutual convenience, that reciprocal privileges should be allowed. This idea is by no means in conflict with the general principle that distance is the most efficient neutralizer.

The good feeling and understanding which I have advocated will be productive of a tendency to keep down unnecessary pole construction, and if either interest have a pole line through a certain territory, and if the other party have but a few wires going in that direction, it is doubtless often the best policy and practice to make the existing pole line available for both. By suitable agreement on this head, both telephone and electric light systems are enabled to use each other's poles on occasion, and thus to carry a sporadic line, and accommodate a customer in districts which could not otherwise be reached, at least with due regard to economy. It is, of course, understood that an electric light company thus stringing wires on the poles of a telephone company must properly run its wires so as to produce at most a minimum disturbance, and that a telephone company taking its chance on electric light poles must not expect first-class results, unless it be returned through the region of disturbance. The responsibility in the latter case is on the owner of the telephone wire alone.

If both sides of the street be fully occupied, and it should be really necessary to carry a main route of wires of both systems on the same side of any street, no other street being available (a state of affairs which ought not often to exist), it would, I should say, be better for them to be upon a single line of large poles than for each company to provide its own poles, and thus to incur the enmity of abutters, property holders, municipal authorities and iconoclasts generally, for a uniform style of construction can then be adopted; and as the telephone current is the weaker, the telephone poles should carry both sets of wires, and the construction should be supervised by its officials. This procedure is, however, only admissible if no other route can be found for the wires of that concern arriving last on the ground; and I repeat that wherever circumstances will permit, the width of an ordinary street at least should intervene between the wires of the two systems.

Electric light and power circuits ought always to be metallic, and in fact every self-respecting electric light circuit *is* metallic; this, however, being altogether without regard to its relations with contiguous circuits of other classes. But a lighting or power circuit which is contiguous to telephone circuits must not only respect itself, but must respect the telephone circuits also, and hence must not only be a metallic circuit, but must have its two wires parallel and as close together as possible, so as to be practically equidistant from the telephone wires; this, in order that the inductive effect exercised by the outgoing and incoming wires may be equal and opposite.

Where the distance of the width of the street is observed the parallel return wire frequently provides all the necessary neutralization, and prevents disturbances, for the neutralization is necessarily more perfectly effected as the distance of the two wires of the electric light circuit from the telephone wires is increased, because the distance of the two wires of the lighting circuit from one another is a much less factor in a greater distance, such as the width of a street, and the two wires therefore operate much less independently than is the case when each wire is almost as near to a group of telephone wires as it is to its own mate. It is, however, often found (and especially when the two sets of wires are on different horizontal planes of the same poles) that even though the two wires of the lighting circuit be substantially equidistant from the telephone wires, perfect neutrality and noiselessness is not secured; and the degree of remaining disturbance is greater or less according to the distance between the wires of the two systems and the distance that the said two sets run in parallel contiguity. This remaining disturbance manifests itself because the electric light circuit is not balanced. If, for example, one of the two sides of a lighting circuit be made to serve one or more lateral loops, while the other runs straight, or if one be connected with a greater number of lamps than the other, there is no balance; the electrical centre of the main line does not coincide with the mechanical centre, and one of the two wires exercises a much greater inductive influence than the other, the result being noise. By arranging the electric light circuit so that each side shall have an equal number of loops of like length, and an equal number of lamps or motors, and then by transposing or crossing the two wires of the lighting circuit about every fourth or fifth pole the disturbance may be totally suppressed.

Such care in construction will most naturally be objected to by electric light and similar companies on the plea of expense, especially by such as have already constructed their lines in a style regardless of the rights of others; yet only by an insistance upon such conditions, when the two systems of lines are in close proximity, can the business of telephone companies be protected.

It may also be objected that since the parallel return wire cross connected at intervals with the outgoing wire is a remedy for inductive disturbances, it is one which should be applied by the telephone companies, and to the telephone circuits, as being the complaining party. But as to this, in addition to the already stated fact, that in nearly every case where the pernicious effects of induction are experienced, the telephone company was already in business and its wires in place, and that the disturbance originated with the advent of the electric light wires, and that common justice requires that the aggressor should apply the remedy, it may with reason be rejoined that the number of the electric light wires is much less than that of the disturbed telephone wires, and, therefore, the remedy may be applied to the former with much greater ease and at much less expense.

We have considered the preventive or remedial measures which are applicable to this evil; and it seems clear that the right time for suggesting the propriety of observing these conditions of neutral construction, is before the work has been done, and it is probable that the owners of disturbing wires will be much more willing to heed them, in originally arranging their wires, than where subsequent alteration is required; especially as in original construction, the plans suggested would not necessitate the numerous joints inseparable from later transpositions.

In any case, whether such remonstrance or suggestions as may be offered, tending to harmless construction be properly received and acted upon or not, it is our duty to offer them, and so to place

ourselves in the right, and in this unmistakable position of having, at least, done our part in objecting to improper, and in stating our convictions of what constitutes proper construction.

I have already alluded to electric railways, and to the fact that the weight of the evidence in regard to disturbances developed by them upon telephone lines tends to show that these are due not to induction, but to actual leakage of electricity from the railway conductors to the telephone lines.

There are several classes of electric railway: first, those which utilize the rails for both outgoing and return conductors. Second, those which employ a single overhead conductor, using the rails as a ground terminal or return. Third, those in which the two main conductors are both in a conduit, to which access is had through a slit in the same way as a mechanical cable road is operated, trailing brushes or springs being led through the slit. Fourth, railways which carry their own electrical energy in the form of secondary battery cells. Fifth, railways which employ two overhead conductors—one as the outgoing and the other as the incoming line.

Of these plans, the first and second are very detrimental to the satisfactory operation of telephone lines; the fourth is perfectly harmless in all respects; and the third and fifth usually are also, and may be readily so made when they are not. All that is necessary to that end is to exercise such care in construction as to insure that the main conductors are properly insulated, and in the case of the fifth plan, that the main conductors are also prevented from coming into contact with overhanging branches of trees.

A great number of electric railways are built upon the second plan, and where they are run near telephone wires invariably exert a pernicious influence thereon, which is largely due to the imperfect return or earth terminals furnished by the rails; a portion of the current passing from them through the earth to the telephone circuits by way of the sub-station ground wires, thus occasioning interference with conversation, and affecting call signal apparatus, and often damaging property.

This class of construction is manifestly improper, both on the score of interference with the telephone wires and as being dangerous, and is of the cheap and reckless order.

When the remedies for its evils are so simple, and consist merely in adding a second overhead conductor, and in looking well after insulation, it would seem that they should be properly and universally applied by reason of the greater security they afford, even though those owning railways may have no just regards for the rights of others.

Telephone companies should, therefore, exert themselves and their influence in favor of the double overhead wire and other safe forms of railway, the former being, in fact, safer in other respects and more economical in operation than railways, which in any way utilize the rails as conductors.

When other systems are already in use, and should it be found impossible or impracticable to persuade the railway company to provide a return wire, and where the telephone service is consequently impaired, the only absolute remedy is that of providing the telephone circuits which are affected, with a parallel return wire.

The disturbances may, however, be greatly softened down or subdued by carrying the ground end of the subscriber's wire from his office or house to some point at a considerable distance at one side or the other of the railway, and by their terminating it instead of at the sub-station itself. Considerable success has also been attained in practice in the amelioration of this trouble by connecting the leading outwires of a number of neighboring disturbed telephone lines with a large common return wire grounded at or near the central station, instead of grounding each in the ordinary way.

If the leak is so great as to affect the annunciators, it is sometimes requisite that the common return wire, instead of being grounded, shall be connected with the several central office terminals of its group of lines, exactly in the same way that its outer end is united to the outer ends of the individual lines; that is, of course, when these are at rest. By adopting this plan the earth connection is, when the lines are not in operation, completely cut off. If the disturbance does not affect the talking, ground connections can be provided for use during talking. If it does, then the return must be retained during talking also.

Though this paper is already long, there are still one or two points on which I should touch. In one of the children's hymns composed by the late lamented Dr. Watts, occur these lines:

> "One sickly sheep affects the flock,
> And poisons all the rest."

And upon the principle thus enunciated, it not infrequently happens that, though but few telephone wires, or even a single wire, be exposed to disturbance originating in and by the causes recited, the trouble is propogated to others by induction, by reason of the close massing of a large number of wires at or in the vicinity of central stations.

Consequently, one wire adversely affected by electric light or railway disturbance may influence deleteriously many others. The lessons we have to learn from this are, that if we have one wire so affected, we ought, in some way, to promptly attack the evil in that wire, remedying the trouble while it is small and controllable; and that it is essentially our duty to remove dead or unused wires at once, unless there is good reason to anticipate an early resumption of use; and even then they should be disconnected from the two terminal stations; and when I say disconnected, I don't mean simply short circuited, or cut out, but absolutely detached, dead wire being one of the most prolific and active agencies of disturbance and danger. True, it costs something to take down wire, and it may be troublesome to put them up again when required, but it is the only safe proceeding, and in such matters the anchor ought to be cast windward every time. It is better to spend a few cents in defense than it is to spend possible millions on account of the misdoings of a dead wire in tribute.

Finally, if the number of disturbed wires be smaller than that of those causing the disturbance, or if it be necessary to run a telephone wire through a region of disturbance, the simplest, easiest and most economical way is not to monkey with the buzz saw, but at once to make the telephone circuit metallic, at least through the region of disturbance, which operation should, moreover, invariably be performed in cases where less drastic measures fail.

THE NEW YORK SUBWAYS.

BY L. F. BECKWITH.

In the following statement I have recorded a few data relating to the construction of electrical subways in the City of New York which may be of interest. The work was commenced in the latter part of 1886, and has been carried on since, with but slight interruption each year during the season favorable to out-of-door operations. The subways as laid out and built have been authorized and approved from time to time by the Board of Electrical Control, and the Consolidated Telegraph and Electrical Subway Co. has been directed by the board to construct them under its contract with the latter. The execution of the work has been intrusted by the above company to its sub-contractor, the Phœnix Construction Co., which has charge of all subway construction in this city.

The subways have been designed and laid out to meet the main requirements of the chief connecting or trunk lines of the various electrical companies so far as they could be ascertained, and so far as they could be conveniently grouped together. The principle of keeping the high tension electric currents for arc lighting and power in subways on one side of each street, and the low tension electric currents for telephone, telegraph, and other purposes in subways on the opposite side of the street, has been laid down and so far adhered to. The question of distribution from the conduits has been wisely left by the Board of Electrical Control to the various electrical companies to express their preference for the method best suited to their special systems. This the companies have been repeatedly invited to do, and while some have responded, and their methods of distribution having been approved as reasonable and feasible, they have been accommodated as rapidly as possible; other companies have held aloof and refrained from action, apparently wasting precious time and neglecting to occupy and secure their commercial field and districts.

The subways built, except the Edison, are all on the "drawing in" system, which provides a group of tubes or ducts extending from one man-hole to another, admitting of the drawing in and out of the electrical cables, and affording convenient access from the street. Different systems of grouping the ducts in the trench, and different materials have been employed, consideration being held of the importance of the line, the question of cost, the durability, tightness against water and gas, etc. Experience has shown us that a main conduit consisting of separate pipes which can be crowded or curved or kept apart is the best adapted to overcome the numerous obstructions met with underground, and frequently diminishes the trenching necessary. Screw-jointed, asphalted wrought-iron pipe laid preferably in hydraulic cement concrete present the greatest tightness of duct against gas and water, united with the greatest strength. The cement pipe and creosoted wood tubes present also features of great merit and adaptability. A special feature of New York subway difficulties is the steam heating underground system, of which the leaks in certain localities greatly interfere with the ducts and cables, precluding the use in such places of materials of construction softening or melting at about 160 to 200 degrees F. In the case of long telephone lines, the desirability of comparing non-metallic and metallic ducts in respect to their influence on low tension currents has also been kept in view. A continuous line of telephone and telegraph subway is now completed about seven miles long, and the above comparison can be made on five to six miles of this length.

The endeavor has been to provide a subway construction that will be most durable and that will give the best mechanical protection to the cables against injury from settlement of the ground, heat, water, gases, etc. The solution of the electrical question of underground working is one that relates to the man-

ufacture of suitably insulated cables, and belongs properly within the province of the electrical companies.

The work accomplished up to September, 1888, is shown in the accompanying table :—

Dorsett ducts, coal tar concrete	235,837	feet.
Zinc tubes laid in hydraulic cement concrete	68,883	"
Creosoted wood tubes	167,175	"
Cement pipe laid in hydraulic cement concrete	216,626	"
Iron pipe laid in asphaltic concrete	131,284	"
Iron pipe laid in hydraulic cement concrete	1,423,722	"
Iron distributing pipe	23,301	"
Edison iron tubes	222,794	"
Grand total length of single ducts	2,489,622	feet.
Grand total length of single ducts	472	miles.
Grand total length of trenches	37	"
Number of man-holes	523	
Total length of telephone and telegraph ducts	376	miles.
Total length of electric light ducts	96	"
Length of telephone and telegraph trenches	19½	"
Length of special electric light trenches	17½	"

Besides the above there is still about three-quarter of a million feet of single duct for telephone, telegraph and electric light purposes, authorized by the Board of Electrical Control to be built, that remains to be constructed, besides contemplated lines.

The standard size adopted for telephone ducts is 2½ inches clear inside diameter, corresponding to a capacity of 100 wires, or 50 conductors in metallic circuit grouped in a lead covered cable. The chief portion of electric light ducts other than Edison ducts are 3 inches clear inside diameter. The man-holes are all of brick laid in cement mortar with 8 to 12 inch walls and concrete bottoms. They vary greatly in form, and are from 8 × 12 ft. to 4 × 4 ft. 6 in. in size, and from 6 to 12 ft. deep. The street casting used has a double cover; the inner cover and rubber gasket are held down by a wrought-iron cross-bar, a bolt and padlock. The covers are practically tight against water.

The systems of distribution in use are as follows: For telegraph purposes, an iron pipe from a man-hole connects underground with a building or with the foot of a pole. For telephone purposes the above method is used, and also in connection therewith, a pipe running up the face of a building to the roof, where, from a fixture, the cable is divided for distribution on the block and surrounding blocks. Sometimes the pipe is carried up through an elevator or ventilating shaft. In addition to the above, in the down-town district, and along Broadway to Union square, an iron 3-inch pipe is laid in the trench above the subway, and provided at intervals of about 50 feet with malleable iron circular distributing or service boxes with screw covers 12 inches in diameter, with side outlets through which a cable can be conducted by a service-pipe into the buildings.

For electric light distribution the Edison company have their special system laid. The "Johnstone" cast-iron distributing conduit, with six ducts and flush boxes, has been authorized to be laid in Broadway, from 14th street to 35th street, for purposes of electric light distribution, and will provide all the necessary facilities for this district.

Up to August 27, 1888, there were 3,567 miles of wire laid in the subways by the Metropolitan Telephone & Telegraph Co. This company has laid a 100-wire lead-covered "Patterson" cable from Whitehall street to 58th street, a distance of about six miles. This cable is believed to be the longest of this size in existence underground. The Western Union company have about 100 miles of wire underground, and the Edison company about 126 miles. The Brush Electric Illuminating Co. are putting an 8-conductor "Standard" cable in the Broadway conduit from 14th street to 35th street, a distance of one mile, making eight miles of electric arc light wire. Other applications for space in the subways and for the construction of additional electric light lines are pending.

UNDERGROUND WORK IN BROOKLYN, N. Y.

BY W. D. SARGENT.

THE extension of underground conduits in Brooklyn has been restricted since my last observations on the subject to short sections, for the purpose of connecting our new buildings in the Brooklyn and Williamsburgh districts with the underground system. All of the new conduits have been made of creosoted wood, the ducts, 3 inches square, inside measure, with the exception of one short section of Macdonald creosoted wood, with round holes, 2½ inches in diameter. It is fully decided, however, that hereafter no ducts will be laid with an opening of less than 3 inches in the clear.

In order to make ample room for the conduits reaching to our principal office, No. 16 Smith street, we have built a tunnel the whole width of the street, high enough and wide enough to walk through, and it now carries 108 ducts with room for perhaps 60 or 100 more. There are special features in this tunnel and method of bringing the terminals of the cables into the building which it is difficult to describe or to reproduce in a drawing. The *Electrical Review*, of Aug. 4, 1888, gives illustrations which will convey some idea of the character of the work, and the members of the association are cordially invited to visit the office and inspect the arrangements for themselves.

The first sections of our creosoted wooden conduits have now been in service four years. There is no evidence of decay, and the ducts remain clean and dry, enabling us to draw in and withdraw the cables without any difficulty.

So far as the conduits are concerned, we think experience has fully sustained our judgment in favor of the creosoted wood.

One of the most important things, after the conduits, in underground work is the man-holes, which should be as large and commodious as possible. Within reasonable limits it is almost impossible to get these man-holes or working chambers too large. While, from the start, we realized the importance of this part of the work, we have in quite a number of instances, been compelled to rebuild and enlarge the man-holes as first designed. Given a conduit of durable material, connecting with commodious man-holes, this part of the underground problem, so far, presents no serious difficulty.

The character of the cables to be drawn into the ducts and the method of distributing wires from them are questions that demand our most earnest attention. Experience has taught us that larger conductors and thicker insulation, together with twisted metallic circuits, are an essential part of perfect service. Conductors of .035 to .040 of an inch in diameter, insulated to .125 of an inch in diameter, and twisted in pairs, with 100 to 104 wires, or 51 or 52 metallic circuits, make up a cable of from 2 to 2¼ inches in diameter. Such a cable will weigh between 4 and 4½ pounds per foot, according to the amount of lead; and on account of the tendency of the lead pipe to buckle in bending, we do not believe that it is practicable to handle cables of larger diameter and weight. The consideration of these facts led us to decide that our ducts should hereafter be 3 inches.

We are using nothing but the lead covered type of cable, some of which has been in service underground for four years and is still in good condition. Of the cables which were laid four years ago, those covered with pure lead appear to be more than half eaten through. One that has been drawn out during the writing of this article has been underground for two years and is badly corroded, there being holes eaten in it in many places nearly one-sixteenth of an inch in depth. Of the cables furnished by the Western Electric Company at the same time, in which there is a small percentage of tin mixed with the lead, the corrosion is very slight, and we are led to believe that cables covered with this alloy will last from three to four times as long as those covered with pure lead. We believe that if in addition to the tin the cables were drawn through a bath of gas tar or asphaltum, then covered with a good stout braid and run through the gas tar or asphaltum again, the cables would be practically imperishable, so far as the outside covering is concerned, and it is a question whether this additional expense would not be justified by their increased length of life. It is certainly worth the trial.

The air-tight terminals which were put on all our lead cables more than a year ago, appear to have removed all the difficulties which we formerly had at that point, and the tests of our cables, making due allowance for temperature, etc., show that there is no deterioration during the past year.

Of the cables mentioned by me last year, one of 7,180 feet, containing 100 wires, twisted indiscriminately, manufactured by the Western Electric Company, has been reduced by the change to the new central office to 6,344. Tests made Aug. 16, 1888, give an insulation of 800 megohms; capacity, .22 microfarads; resistance of the conductors, 43¼ ohms per mile. The conductors are .038 inch in diameter, insulated to .088 inch. For a time during the past year all the conductors were in service, but recently the trunk lines to the Bedford office have been taken out, and there are now 80 wires working through it. The condition of this cable in regard to cross-talk is the same as last year. That is, it is not bad enough to prevent its use.

The cable manufactured by the New York & New Jersey Telephone Company, with 100 wires, twisted in pairs, has been reduced to 6,117 feet. Tests on August 19, 1888, give an insulation of 89 megohms per mile, capacity .275 microfarads, and the resistance of the conductors 48 ohms per mile; temperature in both these cases being, in the air, 80 degrees, and of the water from the hydrants 73 degrees. We assume that the temperature of the water from the hydrants is the temperature of the air in the conduits. Seventy-four wires are working through this cable, and the cross-talk is no worse than last year, and is not so bad as to prevent its constant use. In both cases all the dead wires are kept grounded at the cable terminals.

The greatest length of cable we have now underground is 11,800 feet, between our Bedford street and Williamsburgh offices, consisting of 100 wires, twisted in pairs, the pairs broken up at all the splices; conductors .035 inch, insulated to .075. The insulation of this cable is 99 megohms per mile; capacity, .26 microfarads; resistance of the conductors, 47 ohms per mile. Seventeen conductors in this cable are in use for trunk service between the two offices, the rest of the wires being grounded close to the terminals at both ends. The cross-talk in this cable is very slight, and is indeed less than in the Western Electric cable of 7,000 feet. We received complaints from both these offices that the talking by subscribers through this cable was difficult and unsatisfactory. A special investigation of these complaints at the points they

originated demonstrates that the difficulties complained of are not in the cable, but rather in the condition of the transmitters and instruments in the various offices and carelessness of the subscribers. Considering this cable as a whole, two miles in length, its electrical qualities are: Insulation, 50 megohms; capacity, .53 microfarads; resistance of conductors, 94 ohms. We are inclined to think this is about the limit of good working in that type of cable, and that the complaints we are getting about the service over it are due to the fact that it loads up the circuit so that there is no margin for any deficiency in the subscribers' circuits connected to it; whereas, if its efficiency were higher, there would be a margin to cover such defects, and complaints would be prevented. There is no doubt that the reduction of the cross-talk and the increase in the capacity is due to the fact that 83 of the 100 wires are grounded at the terminals, and that when the whole cable is put into service, this condition of affairs will be changed more or less; that is, the capacity will diminish and the cross-talk will increase.

It was a consideration of the difficulties to be encountered in the use of greater lengths of this type of cable, which the above experience emphasizes, that decided us during the past year to make a special cable for our trunk lines, doubling the weight of copper and thickness of insulation. This resulted in our ordering three miles of cable, conductors .052 inch in diameter, insulated to .125 inch, 60 wires laid up indiscriminately, and during the past two months two miles of this cable or 10,560 feet, have been put up on the elevated railroad structure, connecting the Brooklyn central office with the Bedford central office. The insulation is between 1,200 and 1,500 megohms per mile; capacity, .27 microfarads, resistance of conductors between 21 and 22 ohms per mile, at a temperature of 74 degrees. This cable, though of the same length as the one between the Bedford and Williamsburgh offices, just mentioned, gives surprisingly better results, the cross-talk being very slight and the volume of sound full and strong. Forty of these wires are grounded at the cable terminals, and 20 are in active service.

There does not seem to be anything in the electrical measurements to indicate what causes the difference in the practical working of the two cables, but the results are gratifying and seem to plainly indicate that increasing the weight of the copper and thickness of the insulation is a step in the right direction, and I am inclined to think that grounded trunk wires of this last type may work successfully between our various Brooklyn offices, the distances between which do not exceed two and one-half miles.

All the new cables we have used this year have been of 102 wires, or 51 pairs, twisted, laid up in regular cable form, in alternating reverse directions, conductors .035 inch in diameter and insulated to .125 inch. The insulation of these cables when placed in position underground ranges from 1,500 to 2,000 megohms, capacity from .17 to .18 microfarads, and the resistance 52 ohms per mile. We believe that this type of cable will fulfill all the conditions required in our underground work, but at the present time we have no length sufficient to give actual working results.

The transition period between grounded and metallic circuit systems will be very troublesome and annoying, and may last several years. It is our intention in ordering the type of cable just described to make provision in the man-holes for joining the sections together by devices which will enable the joints to be opened readily without cutting the cable and the pairs broken up in order to prevent cross-talk on grounded circuits, and, at the same time, allow of access to them for straightening them through when twisted metallic circuits are required. The necessity for getting at the joints in this way from time to time, and the space required to accommodate connecting boxes, is another argument in favor of large and commodious man-holes.

The durability of lead pipe, with a slight mixture of tin, the maintenance of a uniform and high insulation, together with uniform resistance of conductors after four years of service, are indications of length of life that are very encouraging.

Up to the present time we have met with no serious accident in our underground work, either from explosions of gas or the men being overcome with foul air. We believe it quite likely that gas is not as plentiful in the streets of Brooklyn as it is in many other cities, and therefore the accumulation in the ducts and man-holes is not so great; but we have been very careful not to spare any precautions that would insure our safety.

The Dorsett conduit, of which we have five miles, with ducts two inches in diameter, has proved to be very unsatisfactory, and the ducts, on account of inequalities at the joints, will only permit of a cable an inch and a quarter in diameter being drawn in. This reduces the capacity enormously, and is, therefore, a source of inconvenience to us.

It is plainly proved that the use of underground wires reduces the margin of good working very largely and will, therefore, require that extraordinary care must be taken to bring the service to its highest efficiency at all other points.

The most fruitful source of our trouble is the transmitter and battery, and while there have been very great improvements during the past year or two, there is still room for much more improvement before we reach perfection. The numerous contacts, in the magneto-bells and other apparatus, need especial attention and care, and platinum should be used wherever possible.

Another source of trouble is carelessness in running the wire from the insulator outside the building to the instruments in the building. The writer knows of many cases where the subscriber's wire is run through the window casing with the ordinary cotton covered wire and but little care taken in the inside of the building to keep it away from possible dampness.

As the mileage of underground wire increases, these and other faults, now overlooked, will become more and more apparent, and the expense of maintenance and inspection will be largely increased. There is only one way to bring back the easy working margin we have enjoyed on pole wires, and that is by the use of metallic circuits, and the sooner we get down to that basis, the better it will be for the service.

The following shows the actual extent of our underground work on Sept. 1, 1888:—

	Miles.
Length of conduit	15.17
Length of duct	105.5
Length of cable	22.93
Length of conductor	2,053.8

Nineteen hundred and thirteen subscribers are working through underground wires, using 1,229.9 miles of wire.

THE TELEPHONE EXCHANGES FOR THE CITY OF NEW YORK.

BY E. F. SHERWOOD.

THE Metropolitan Telephone and Telegraph Company has 7,300 subscribers, operated by eleven exchanges which are furnished with the following systems: John, Thirty-ninth and Harlem exchanges use the Western Electric multiple; Pearl, New, Nassau, Murray and Twenty-first street exchanges use the Chinnock system; Spring street, the improved Chinnock system, adopted by Mr. Jos. P. Davis, formerly general manager of the company; Fulton and Beaver street exchanges use the Law system. The John street exchange has 799 subscribers and 40 trunks distributed among them. The Thirty-ninth street exchange has 1,108 subscribers and 39 trunks, and Harlem has 374 subscribers but no trunks terminating outside of the trunk sections. The reason that we have trunks at the two former exchanges among the subscribers is to connect the system with points not accessible or convenient to reach with trunk calling wires.

To operate the boards during the busiest hours requires the following number of operators: John street, 14 operators, 57 subscribers per operator; Thirty-ninth street, 21 operators, 52 subscribers per operator; Harlem, 6 operators, 62 subscribers per operator; but counting the trunk wires according to the business done over the average subscriber's wire will be equal to adding 73 subscribers to John street, and 70 to Thirty-ninth street, thus increasing the average at John to 62 and at Thirty-ninth to 56. The reason we have a greater average at John and Harlem is that they are situated in the centre of business district, while Thirty-ninth street being a manufacturing and residence district a larger portion of the business is trunk.

We are using what we term trunk calling wires between the various exchanges, one terminating at John street and the other at Thirty-ninth street, for calling all trunk connections to the exchanges named.

There is an average of 3,000 connections per day called over each of these wires, and as each connection is ordered off again the number of orders is increased to 6,000. All of this work is done by two operators at each of these exchanges, and could be done by one if a whole section of the board was within her reach. We divide the trunks, one half being used for receiving and the other half for sending. Those we receive on are not multiple through the board, but end in cords and stand open at all times except when in use. When a number is called on any given trunk the connection is immediately made and is ready for ringing, this being done by the office calling, as we make the office where the call originates responsible for the connection. If the number called is busy we throw battery on the trunk, dropping the annunciator as a signal. We find this system very advantageous, as there is no delay in calling or clearing trunk connections and the service is made prompt, as shown by 10 trunk connections made and conversations started with subscribers in six and one-half minutes.

At the exchanges which have the Chinnock system, each operator at the cases answers 100 subscribers and completes all local connections, using a local calling wire and a set of local trunks, which connect all the cases together. The calls for trunk connections are written on slips of paper and passed to the operators who control the trunks to the various exchanges. Ten trunk connections were made and conversations started through this system in twelve and one-half minutes.

The Fulton and Beaver street exchange have, together, 410 subscribers, and are operated by nine operators and one chief operator. All local connections are completed by the operator

who receives the call over the calling wire, and trunk connections are completed by the operator at the exchange for which the subscriber calls. The Law operator simply connects the subscriber's wire with the trunk wire and rings down the annunciator, when the operator answers and ascertains from the subscriber the number wanted. Ten trunk connections made through the Law system were completed and conversations started in 4¼ minutes, ten local connections in 2¾ minutes.

The number of trunk wires connecting the exchanges in New York city is 532 and average 60 connections per day, and as this average could be increased to 70 per day, the number of subscribers could be increased 600 without increasing the trunk facilities. To other exchanges we have 187 trunks, and with those the service is quite satisfactory, and especially so with the new Brooklyn exchange of the New York and New Jersey Telephone Company, and the service is prompt and satisfactory in every particular.

By the consolidation of the seven exchanges in the new exchange at 18 Cortlandt street, 206 trunks which connect these exchanges will be abolished, and the number of trunks to all other exchanges may be reduced, for the total number divided among the seven exchanges will not be required when they are all accessible to an operator in the new exchange. The new switchboard at No. 18 Cortlandt street will soon be completed and the consolidation of the seven exchanges made. It is wired for 5,100 subscribers and 900 trunk wires. The subscribers' operators will attend to 50 or 75 wires, according to the business done at different sections of the board. Trunk calling circuits to the other exchanges will be in operation, each receiving trunk operator attending to 50 wires. The local battery of each operator's outfit will be two cells of storage battery, one to be in use during the day and the other at night. The one in use during the day will be charged at night from the main storage battery, and the night battery will be charged from a dynamo during the day. All wires will approach the exchange through the underground system, the underground cables terminating in the cellar. From there they will be carried to the distributing board in the exchange by 334 conductor cables. The consolidation of the several exchanges will be beneficial in many respects. The service will be improved, the great volume of "sent" trunk business will be reduced from 20,000 to 8,000 connections, and the running expenses of the exchanges will be reduced about $2,700 per month.

One thousand five hundred and twenty-seven miles of wire are now underground, and 2,784 separate wires are altogether or in part so working, most of which give general satisfaction. The underground facilities are rapidly increasing, 18 miles of 102 conductor cable running from 18 Cortlandt street to various points are now completed, and will be used when the exchanges are consolidated. Eight and three-quarter miles of the same cable will soon be run for trunks from 18 Cortlandt street to the other exchanges, thereby making the trunk service from this exchange entirely underground and doing away with the delays and expense of crossed and broken trunks, and will do away with the danger of crosses with wires carrying a heavy current, which proved so costly in connection with the burning of the Thirty-ninth street exchange, on which a few remarks may be of interest.

On May 23d the Thirty-ninth street exchange was set on fire by a cross with a wire carrying a heavy current, and one and one-half sections of the board were burned out. The work of restoring the Western Electric multiple board after it has been burned and saturated with water can only be appreciated by those who have had to do it. In order to straighten out the wires it was necessary to make 1,260,000 tests, to splice 9,600 broken wires, to replace 16 cables which were destroyed from the switchboard to the cupola, and dry out the saturated portion of the board. The work of getting the lines in complete working order was delayed by the accumulation of line trouble while the troublemen were working in the exchange, but the switch-board and all the lines were in complete order two weeks from the date of the fire.

THE TELEPHONE.

BY DR. S. M. PLUSH.

No discovery or invention was ever born at a time when the world was more ready to receive it than that of the telephone, notwithstanding which, great talent, perseverance and wealth were necessary to its successful introduction. The uncertainty which unfortunately hedged it about gave rise to temporary work and machinery, which has simply been renewed to the present time, and to-day the vast telephone system of the country is but a network of unreliability and temporary make-shift. Even the head centres or main exchanges (with but few exceptions), representing untold labor and expenditure of large sums of money in machinery and apparatus, are held by but a feeble tenure.

At that period but little time was given for consideration, and a forecast of what the future would be was difficult. The growth of telephone plants was without a parallel in any industry; the demands made upon them were greater than their means of supply; competent labor was not in the market and efficient machinery had not been devised.

The difficulty of meeting the requirements of a large number of subscribers at a given point early presented itself, and gave rise to a number of small exchanges, even in the most populous districts. This, together with the resistance on the part of the public authorities to the erection of necessary conductors, set the seal of fixidity upon what is manifestly a great hindrance to good and reliable service, while in nowise conducing to economy. The expense for rents, light, fuel, trunk lines, and the introduction of so many additional connections into circuits call loudly for aggregation, and we believe the tendency is in this direction, and the time not remote when trunk lines will be known only as a means of reaching points far distant.

Probably the greatest drawback to-day to the complete development of our telephone systems is a growing tendency in legislative bodies to regulate prices to be charged for service, which, in effect, is simply to paralyze its growth and efficiency. Were the telephone the only means of communication, some regulation might be wise; such, however, is not the case—we have the postal, telegraph, and messenger service, each filling its own peculiar sphere, as regards reliability, speed and cheapness. The telephone should, so far as practicable, combine all of these features, but neither should be sacrificed to the others; to regulate either must be at expense of the whole.

When the field is once open to competition, that company which rigidly adheres to reliability and promptness in its service will not suffer through paucity of its finances.

Nothing in my opinion has operated more to the disadvantage of both the telephone companies and their subscribers than cheap rates. Many, through this means, have been induced to become subscribers to an exchange who have no real need for the facilities it affords. This lends a tone to their business, it is true, and serves in a measure as a card of respectability. Their place at once assumes an imaginary importance, and if there is any one thing that delights them more than another, it is having some real or fancied business with a leading and substantial firm. This they manage to have at frequent intervals, thus taking the time and monopolizing the wires of others, to their detriment and absolute loss. Important business is thus delayed and the value of the exchange materially lessened.

Busy houses to-day find it necessary to have some one in constant attendance at the telephone, and yet many calls are so delayed as to be useless. It is but fair, therefore, that their interests should have as many safeguards thrown around them as possible; that their conveniences and time may not be engrossed by frivolous questions in which they have no interest whatever. In other words, an exchange may be so large as to be comparatively worthless.

Constant effort towards speed, both of connection and disconnection, is being made, thus making a greater number of calls in a given time possible, and thereby removing the limit, which would otherwise soon be reached; but this limit must ultimately be reached, and what then? Even now requests for discrimination in making connections are not uncommon.

At the present growth of our largest exchanges the time must come when a more select means of communication will be demanded by the business public. That is, an "exchange" for business ("select," if we may so term it) where a party to become a subscriber will not only be required to pay his annual rental for service, but must hold a certificate of membership as well.

George Eliot remarks, that we began life, knowing little and believing much; a few years of experience, however, and in many cases the quantities are inverted. This aptly applies to every man connected with electrical science and mechanics, particularly the telephone and its environments. We live to-day in the same atmosphere we did ten years ago; nothing has materially changed, except ourselves, and we only in credulity. True, our experience has been great and varied, and has taught us in some instances how not to do it, and by this slow but certain method of evolution may in time teach us how to do.

It is difficult for us to realize that we are gradually making a history, and that the records of the great telephone must eventually be written; that we are each of us contributing thereto; that no matter how small a factor each may be, he is a part, and that at last his individual size must be determined by the magnitude of the whole. It behooves us, therefore, to see that the foundations of the telephone, which are now being laid, shall be solid and firm, that every right, every franchise, shall be permanent, every structure substantial, every centreing point immovable and every method correct, and to this end the energies and intelligence of those associated with the telephone can be profitably directed.

.... THE future system of electric railway distribution will be one in which the current will be transmitted from the generating station at a high electromotive force over well insulated main conductors, and in which the current will be converted into a lower electromotive force and supplied to the motors by means of sectional working conductors at a safe and economical working pressure.—*Elias E. Ries.*

LIGHTNING.[1]

BY S. A. VARLEY.

(Continued from page 400.)

I FEEL the title that heads this article must seem somewhat of a misnomer, and as a matter of fact, I wanted to alter it when it was too late to do so; but it was the observation of the action of a lightning discharge on a telegraph circuit in 1856, which directed my attention to magnetic inertia, the source, as I believe, of all the so-called self-inductive phenomena, and it was the late lectures on the protection of buildings from lightning, by Professor Lodge, that led to the writing of the article, and hence the title which was chosen.

By directing attention, as I have now done, to the important part which the inertia of magnetism plays in dynamos, I think I may claim to have made a step in advance, for I consider I have linked to a certain degree the mechanical force developed in the steam engine with the internal forces in the mass of matter composing the machine, and this, as far as I know, has hitherto never been attempted to be done; further, I think I have thrown light on the *modus operandi* of the transmission of energy by dynamo machines.

In a previous portion of this article, I have likened the development of energy in a dynamo to a bombardment of a mass of matter which produces heat in place of motion of the mass; but what I wanted to convey would, I think, be more popularly explained by a further illustration. Assume we have a large mass of matter suspended in the atmosphere, the attraction of the earth being balanced and neutralized. If force be applied, this mass will be set in motion, the rate of motion progressing directly as inertia is overcome. After motion has been imparted to the mass, it will continue to move unaided, as force is indestructible; but the friction of the atmosphere causes a certain amount of skin resistance, and force sufficient to balance this will have to be applied to maintain the motion, such force being wholly consumed and dissipated in the form of heat; and so it is when an electric circuit is closed through the insulated wire of an electro-magnet, the inertia of magnetism has to be overcome to allow of the motion of the electric atoms (if I may so term them) resident in matter, and all that is necessary to maintain the electric motion which has been set up is energy sufficient to balance the resistance that all conductors oppose to the transmission through them of electric motion, a resistance analogous to the skin resistance of a mass of matter moving through a viscous medium.

If the steady flow of the electric atoms be suddenly checked, then the inertia of magnetism, the equivalent of stored up energy comes into play, and acts in a precisely analogous manner to the stream of a water ram when its flow is suddenly checked, the total amount of energy becomes imparted to a smaller number of the electric atoms, and consequently the electric potential is increased, such potential being increased directly as the amount of resistance opposed in its path. Magnetism and electricity appear to me to be separate forces, and they are so intimately associated with what we understand by the word matter, that the older I get the more I regard them as being a species of matter, if not actually part and parcel of it. Now, if we regard electricity and magnetism as distinct entities or atoms, then, I think, we can obtain a general comprehension of electro-magnetic phenomena, and the *modus operandi* of the transmission of force by supposing iron and magnetic substances to possess a much larger number of magnetic atoms than non-magnetic matter, and that directly as the number of magnetic atoms in a conductor, so is its resistance to sudden atomic motion or polarization. The mass of iron composing a dynamo armature possesses a very much larger number of magnetic atoms than the insulated copper wire surrounding it, and therefore when the armature is revolved through the magnetic fields of alternate direction, the mechanical force of the engine is deflected, as it were, and instead of overcoming the inertia of the magnetic atoms and magnetically polarizing the armature, it sets the electric atoms resident in the convolutions of insulated wire in motion in alternate directions instead, and conveys along with the electric currents developed the energy consumed in imparting motion to the dynamo, in a somewhat parallel manner as when an India-rubber ball is thrown against a wall, and its direction of motion, as well as the energy imparted to it, is altered.

If an electric circuit be closed through a straight conductor, the conductor exhibits magnetic phenomena, iron filings are attracted, and a magnetic needle subjected to its influence and free to move, will take up a definite position which has reference to the direction of the electric current. If the conductor be insulated with cotton or silk and wrapped so as to form a solenoid, there will be an increase of magnetism produced when the electric circuit is closed through it. This arises from two causes: 1st, the magnetism developed is concentrated in a smaller space; and 2d, as a consequence of this concentration, arising from the greater contiguity of the coils, they are brought more under the influence of one another and act inductively and thus enhance the magnetism produced.

It will be observed if the circuit through the solenoid be divided, the spark produced in the act of breaking contact will be a heavier one than occurs if the battery wires be simply brought together and separated without including the solenoid in circuit.

If the solenoid be placed in the interior of a second solenoid and the circuit of No. 2 solenoid be closed through a galvanometer, a momentary deflection will be observed on closing No. 1 solenoid in the battery circuit, and a second momentary deflection of the galvanometer needle, but in the opposite direction, will be noticed when the battery circuit is broken.

It will be further observed that the spark produced by the division of the battery circuit through No. 1 solenoid is greater if No. 2 solenoid is open at the time, than the spark produced if No. 2 solenoid circuit be closed.

If a cylinder of soft iron be inserted in the interior of No. 1 solenoid, then all the phenomena which have been just described will be observed, but in a greatly enhanced degree. Further, it will be observed, that if the circuit through No. 1 solenoid be opened and closed rapidly, or if currents be sent through it in alternate directions, the soft iron core will be found to have become heated, and that the heat developed will be greater if the circuit of No. 2 solenoid be kept open, than the heat that is developed when No. 2 solenoid circuit is kept closed.

If the iron cylinder be replaced by a core composed of fine iron wires, then all the effects above described will be still further enhanced, with the exception of the production of heat in the iron core which, if not now actually imperceptible, will be found to be very much reduced.

I need not enter into detail as to how the phenomena referred to are produced, for what has been stated is common knowledge to most of your readers; but what I do want to direct attention to is that there is too great a tendency for those trained in the schools to regard such phenomena separately, instead of grasping them as a whole and perceiving that they are simply incidents arising out of first principles.

For example, scientists speak of extra currents, secondary currents, and Foucault currents as distinct from one another, and we have had lately added to this list self-induction, and new terms suggested to be used in connection with it.

Now I venture to assert extra currents, secondary currents, Foucault currents, and self-induction are produced in the same way, and that they are all referable to the inertia of magnetism.

Professor Hughes' researches demonstrate, as might be naturally expected, that the conditions most favorable for the exhibition in a conductor of what is called self-induction is the exact converse of that for the development of magnetism in a mass of soft iron.

A solenoid of copper wire will, I venture to say, exhibit more powerful self-induction than a straight wire, and for the same reason that more magnetism is developed by a helix than a straight conductor.

For the development of what is termed self-induction in a straight conductor, a cylinder is the best form, as the molecules of which it is composed are in closer contiguity in a cylinder than in any other shape, and consequently the conditions for magnetic induction between the molecules are more favorable. On the other hand, a ribbon conductor is the one in which the molecules are separated to the greatest extent, and therefore the conditions are the most unfavorable for magnetic induction between the molecules.

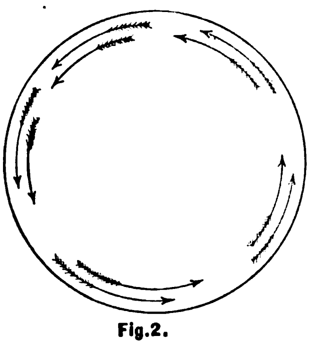


Fig.2.

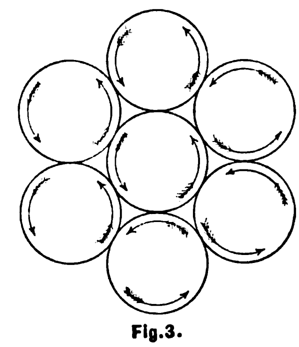


Fig.3.

If an electric current, which may be termed the magnetizing current, be sent round a soft iron cylinder, as a consequence of the inertia of magnetism, a temporary current is set up in the iron and passes round it in an opposite direction to that of the magnetizing current, and a solid cylinder of iron is the best form for favoring the development of such temporary currents.

If the cylinder be replaced by a bundle of iron wires, the temporary currents set up round the wires pass each other in opposite directions and neutralize one another, and the tendency to form such currents is consequently checked.

If an electrical current be sent through a cylindrical conductor, rings of magnetism will be formed at right angles to the direction of the current, and these rings, which we will call magnetic currents, will flow round in a uniform direction.

If, however, the solid conductor be replaced by a bundle of

1. From The *Telegraphic Journal and Electrical Review* (London).

conductors formed of wires of small sectional area, then the tendency to form magnetic currents will be greatly interfered with, as the magnetic currents formed in each wire will be in the opposite direction to that of its neighbor, or more correctly, will pass one another in opposite directions and neutralize one another. Figure 2, represents a cylinder of iron in the act of being magnetized, the arrows indicate the temporary or, as they are termed, the Foucault currents flowing in the interior.

Figure 3, represents a bundle of iron wires in the act of being magnetized. It will be seen by the arrows that whatever currents are set up oppose one another, and therefore tend to stop their formation.

Now if figure 2, be regarded as a cylindrical conductor, the arrows will indicate the magnetic currents flowing in a uniform direction, which develop magnetism also in a uniform direction, and favor self-induction; and if figure 3 be regarded as a conductor composed of a bundle of wires, it will be seen that the tendency to form magnetic rings is prevented, as the direction of the magnetism which would be developed in any of the conductors would be balanced by that developed by its immediate neighbors, and therefore the conditions are not favorable for magnetic polarization, or, as it is termed, self-induction.

I think it has been now fairly shown that what is termed self-induction is magnetic inertia, and that magnetic inertia in a conductor is manifested directly as the quantity of magnetic matter brought under the influence of the *whole* of the electricity set in motion *throughout* the conductor.

That for this reason a ribbon conductor has less self-induction (magnetic inertia) than a cylindrical one, and a straight cylindrical conductor has less inertia than the same conductor when formed into a solenoid, and, further, this solenoid has less inertia than the same solenoid when a bundle of iron wires is placed in its interior.

We know the conditions which favor the development of magnetism, and these conditions harmonize throughout with the conditions which are found to favor the production of the phenomena attributed to self-induction.

If self-induction were due to electrical inertia, as Professor Lodge and others seem to believe, then it would be difficult to assign a reason why a ribbon conductor should not exhibit it in as great a degree as a cylindrical one.

The inertia of matter is directly as its weight, and electric conduction as the weight of the conductor multiplied by its length, the shape of the conductor (assuming it to be a uniform section) not influencing the conducting power in any way. Now, if self-induction were due to electrical inertia, it might be fairly expected that it would so far harmonize with electric conduction and material inertia as not to be affected by the shape of the conductor; but grant, for the sake of argument, that the shape may have an influence, then the self-induction manifested should not be affected in any way, whether the conductor be in a straight length or formed into a solenoid. Now I have never actually tried whether a conductor in the form of a solenoid will exhibit the so-called self-inductive phenomena in a greater degree than the same conductor when straight, but I will venture to stake my reputation as an electrician that this will be found to be the case, and if it be so there can be no escaping from the conclusion that self-induction, as it is called, has its source in the inertia of magnetism, and is magnetic inertia pure and simple.

What is understood as the development of electricity, is generally attributed to an internal movement in the conductor which sets in motion the electricity associated with matter throughout, the conductor energy being locally dissipated directly as the resistance of the conductor through which a given quantity of electricity is passing. I myself am strongly of opinion that electric conduction is atomic as distinguished from molecular movement. There are reasons that lead me to conclude that electricity and gravity are forces as distinctly separate from one another as the material elements with our present knowledge would seem to be, and, therefore, gravity and electricity are not *directly* convertible.

There are reasons also for believing chemical affinity and electrical attraction are one and the same thing, and are concerned in the organization of matter and the formation of the atoms into molecules. Cohesion and gravity, on the other hand, would appear to have their origin in a common principle and to deal with matter after it has been formed into molecules binding molecules together and attracting matter in the mass bodily.

Familiar as we seem to be with matter from constantly being brought into contact with it, we know really but little of its constitution; the same may be said of inertia, motion, force, and time, terms in constant use, and the effects of which we come face to face with almost every moment of our lives.

If our scientific schools would only break fresh ground by making researches into the nature of such elementary principles as I have mentioned instead of devoting their lives to the microscopical measurement of data already known, and constructing with the aid of the scientific mechanician more and more perfect measuring instruments, as if the end of science were measurement, then I venture to think our progress in the acquisition of *real* knowledge would be much more rapid than it is.

By far the greater part of the communications brought under the purview of the scientific societies are simply additional literature which often tend to confuse plain issues and by the very mass of elaboration and detail make the acquisition of scientific knowledge more and more difficult. What struck me most at that very interesting exhibition of the late loan collection of scientific apparatus, was the apparatus of Faraday and models of that of Ampere, the whole of which stood on two small tables and could have been reproduced for a cost of a few pounds.

The simple apparatus of Ampere and Faraday was surrounded by the costly accurate apparatus of modern times, the whole of which, if regarded from a purely scientific standpoint, had been chiefly designed to measure, and only to measure, the work accomplished by men of the calibre of Faraday and Ampere.

All we know of motion is that it is relative to matter and that it involves at the very least two atoms, for there can be no such thing as motion in reference to absolute space. I have been disposed to regard motion as a combination of matter with external force or energy of some form, and inertia as the storage of the external force by matter that involves time, an entity we really know next to nothing of.

If the question be asked what is force, our scientific schools have a ready answer. They will tell us forces are modes of motions, and would seem to think we ought to be satisfied with such an answer, which is really no explanation whatever.

For my own part, when I have sat under a certain popular ritualistic scientific preacher or master of style, as he is commonly termed, and observe the very vestments in which he has dressed, his experiments appear to have received more attention at his hands than the truths he professes to be so anxious to inculcate. I could not help my sense of the ridiculous being excited when I have heard him enlarge from his pulpit on the infallible rock on which science is based, and the breadth of view which distinguished his own particular school as contrasted with another school of thought for which he does not disguise his contempt, and I have been unable to resist smiling when he has afterwards given his audience to understand that the nature of force is well understood and explained by the statement that they are modes of motion.

Whoever it was who coined the phrase, "heat is a mode of motion," must, I always feel, have had a lively appreciation of the scientific uses of the imagination.

In a certain sense I confess this phrase may be regarded as involving a truism, seeing every act performed is associated with what we express by the word motion, and what we understand by the word force is largely concerned in bringing about such motion; but if we analyze the phrase, it will be found to be merely a string of words, and nothing more or less than the concealment of our ignorance by the assertion of a dogma; and let me point out what is, I think, not recognized as much as it should be, that all scientific phenomena, if traced back to first principles, will be found invariably to be based on observations of a something which is neither more or less than a dogmatic utterance, and would be correctly expressed by the words, "thus saith nature," a phrase very similar to that which frequently occurs in the sacred writings.

Dogmas have their use undoubtedly, and the phrase, "heat is a mode of motion," shines with a reflected glory, simply because some of our most eminent scientists have been content to accept the dogma as a rallying point or flag; and it is the work they have accomplished fighting under this banner, and this work *only*, which has given a value to the phrase, much in the same way as that given to the tattered rag some distinguished regiment carries into battle, and around which men fight and die, and which in the end finds deservedly a resting place in our cathedrals, because it symbolizes that which distinguishes men among men, and man as man from the greater part of creation.

I must ask your readers to forgive this digression, the only excuse for which I can plead being that it seemed to me to be wanted to be said. Professor Lodge has stated that electricity is not energy, but one of the vehicles by which it can be conveyed, and I have myself, on the whole, been disposed to adopt this view; but some years ago, as the outcome of reasoning on certain experiments, I formed a theory, of which I made a note, which regarded electricity as energy. I, however, put this theory aside, partly because I am so strongly impressed with the feebleness of the human intellect to grapple with the phenomena presented to our gaze by the world of mystery in which we dwell, and partly because, in my opinion, there is too great a tendency to theorize and speculate; but as I have been writing this article the theory I have referred to will keep obtruding itself, and as it now seems to me to harmonize with the general direction of thought of the present time, I propose to briefly describe it. At different periods of my life I have thought I had obtained evidence that time might be considered to be a force; the evidence collected has, however, broken down invariably on more mature reflection. But, although I am disposed now to think that time cannot in any proper sense of the term be regarded as a force, it seems to be certainly a connecting link between the forces, and to have an important influence on them—for example, if a given amount of

energy in the form of force of low potential be brought to bear on a mass of matter suspended in space, the whole of the energy, with the exception of a percentage so small as to be negligible, will be absorbed by the matter and converted into motion of the mass; but if the same amount of energy in the shape of force of higher potential be applied, the percentage of energy not converted into bodily motion will no longer be negligible; and if this given amount of energy be brought to bear on the mass, in the form of force of much higher potential, nearly the whole of it will become converted into heat, and the motion now imparted to the mass will be the negligible quantity. We see from what has been above stated that time is capable of connecting energy with matter in such a way as to determine whether it be simply transmitted or converted at once into local work.

Heat and energy are convertible terms, and there is one case, and *one only*, that I am aware of, where the energy appears to be converted directly into electricity, and that is in the thermo battery. The fact that electricity appeared to me to be produced in this instance in an altogether different way, led me to try some experiments on the development of thermal currents, and the conclusions I came to harmonize with what I believe to be the generally accepted view, that the conditions the most favorable for producing thermo electricity are those that favor a rapid absorption of heat and its rapid radiation through the thermopile; and there seemed to be no escaping from the conclusion, that in a thermopile we have an example of the direct conversion of energy into electricity, and if so, then electricity must be something more than a vehicle of energy and would appear to be a form of energy.

Now if we accept the dogma that heat is produced by an atomic bombardment producing in the matter bombarded atomic motion, it seemed to me electricity might differ from heat simply in being a still more rapid motion, and that thermo currents were produced in a somewhat analogous way to that which occurs in a water ram where energy of low potential becomes converted into energy of a higher potential at the cost of a somewhat wasteful expenditure of energy.

Assuming the views I now venture to promulgate to be correct, and that electricity differs only from heat in being a more rapid atomic motion than the potential or energy of a current would be directly as its rate of motion, and we should have a simple explanation of what I believe to be the fact, that a lightning discharge cleaving its way through a space, it may be, of more than a mile of air, occupies no more time than the spark which discharges a Leyden jar.

The production of heat by electricity would be also accounted for in a natural manner, as when the rate of motion was retarded by resistance it would assume the form of heat, and the retardation would be the measure of the energy expended in breaking down such resistance, whether it be a conducting wire of small sectional area, a glow lamp, or electric arc, or a space of air.

I would further point out the theory now propounded which has been gradually evolved out of reasoning upon experimental observations, and which has forced itself unbidden on my attention, seems to me to link together in one continuous train or natural order of sequence the data already known in connection with the action of gravity, the conversion of motion into heat, the development of electricity, and the transmission of energy by means of the dynamo. For example, when a stone falls from a height energy is imparted to it by gravity combined with time, such energy being a function of the weight of the stone multiplied by the time gravity has been free to act upon it.

When the stone becomes suddenly arrested the energy of motion acquired is given out in a much smaller interval of time than that consumed in its production, and it becomes converted into internal motion or heat, a more refined form of energy and of a higher potential, using the term potential to express rate of motion, and this more refined or purer form of energy, when it is arrested by coming into contact with magnetic inertia, becomes converted into electrical or still more rapid motion, the rate of motion of the electric atoms being determined by the amount of energy arrested and the resistance of the conductor through which the electricity is transmitted.

Having now launched my little theory, and given the reasons for the faith that is in me, I leave it to others to deal with; it may be to explode, to put it aside, or perhaps to ignore altogether.

I now propose to examine briefly statical charge, energy, and the relation of the earth to statical and dynamical electrical phenomena, and afterwards to make a few comments on Professor Lodge's experiments.

None of the theories give a very satisfactory explanation of statical charge, and until we know more respecting the real nature of electricity we can scarcely hope for one.

I confess to a certain mental reaction in favor of the Franklinean theory; but it appears to me nevertheless that statical charge, on the whole, is more understandable on the supposition that what we are in the habit of terming positive and negative electricities are two distinct entities.

Franklin's hypothesis assumes the pumping out of electricity on one side of the dielectric, and its accumulation on the other side, producing a sort of reorganization or re-arrangement of the sum total of the atoms and forces which go to make up what we term matter, and in this way bringing about a strained condition.

Now we are only cognizant of electricity and energy as associated with matter, and we cannot readily grasp the term energy in any other sense than as implying activity; and if energy be motion, then to talk of it as being in a statical condition seems to be a contradiction of terms. We can, however, with less mental difficulty realize energy being balanced by energy, and thus bringing about a condition of equilibrium.

We have an example in a revolving disc, where matter is subjected to force in such a way that the energy exerted throughout the matter composing the disc is in opposite directions. Now, although a rotating disc is not an explanation, it is an illustration that helps us forward in the direction of an explanation of statical charge.

In a revolving disc we have motion imparting energy to the molecules of the disc tending to separate them one from the other; but at the same time, the disc, as a whole, is in a condition of equilibrium, and behaves like matter at rest in reference to external forces, such as gravity, etc.

As the disc has been subjected to a single force, and force is indestructible, the energy imparted cannot dissipate itself by discharge, and the disc continues to revolve, the energy dissipating itself gradually in the form of heat produced by friction at the bearings and the skin resistance of the atmosphere.

Were the energy, however, of a dual character, we could imagine the disc being brought suddenly to a state of rest by the union of the two forces, accompanied by a rapid dissipation of energy, such as we have experience of when a Leyden arrangement is discharged.

The query suggests itself: Can statical charge be looked upon in the light of a storage of energy?

Maxwell has stated: "The total energy of any material system is a quantity which can neither be increased nor diminished by any action between the parts of the system, though it may be transformed into any of the forms of which energy is susceptible."

Accepting the above definition, the phenomena of energy must be attributed to a temporary shifting of the energy forming part of the system; and if a Leyden jar be regarded as a complete system, then statical charge may also be regarded as a production of energy of position, or storage of energy, or more correctly, perhaps, as an approach to it, for we have in the case of the statically charged jar internal forces displaced but not removed, and the organization of the matter composing the Leyden arrangement is not actually altered, but only tending to be so.

If we place two platina plates in a cell containing water, or acid and water, we shall form a Leyden arrangement with a dielectric of very low resistance, the liquid taking the place of the glass insulator. Now, if we statically charge this arrangement by connecting the positive and negative poles of a galvanic battery to the platina plates, there will be not only a displacement of the forces, but an actual breaking down and partial reorganization of the atoms composing the dielectric, and an approach to their union with the platina plates.

In this example we have a statical charge, or storage of energy, of a much greater quantity than is possible with a Leyden jar; but as the dielectric is one of very low resistance the potential to which it can be charged is proportionally low. Nevertheless, the storage of energy under such conditions will necessarily be very limited, for, although an actual breaking down and separation of some of the atoms of the dielectric has occurred, the separated electrically charged atoms do not possess sufficient energy to break down the organization of the platina plates, and so form an actual union with them. Consequently they accumulate as a statical charge only, and by their reaction resist the further breaking down of the atoms of the dielectric, but if sheets of oxydized lead be substituted for the platina plates a breaking down and reorganization of the atoms, both of the dielectric and of the lead, will be brought about, and the storage of energy now possible is consequently immensely increased.

What we have seen occurs in a limited degree with platina plates immersed in acid and water when electrically polarized, and what occurs in a very much greater degree in storage batteries explains what electrical energy is striving to bring about in the matter composing a Leyden jar, and helps us to understand the nature of statical charge.

In a storage battery electrical energy produces a very similar condition in the leaden plates to such as we find to exist in fulminating compounds, gunpowder and organic matter, in all of which we have matter and force locked up together, and in a condition of more or less unstable equilibrium.

I have now, step by step, linked together statical charge, electrical polarization, storage batteries, explosive compounds and organic matter, much in the same way as in a previous portion of this article I have indicated the successive links in the chain which connect the action of gravity on matter with the production at the end of the chain of electrical energy; and I would here point out that if there be a difficulty in comprehending the nature

of a statical electrical charge, it is equally difficult to understand how energy can be confined in gunpowder or organic matter, and I would further point out that the energy given out by a storage battery is very different from the energy directly produced from organic matter or explosive compounds, and the only thing they have in common is that when energy is dissipated, whatever be its source, such dissipation always assumes the form of heat.[1]

Electricity and energy are so intimately related, that it seems necessary to say a few words on the subject of energy.

Scientific progress may be said to be directly proportionate to the accuracy of our knowledge of the forces the scientist has to deal with; and great advances can scarcely be expected to be made by microscopically examining scientific phenomena separately, and simply measuring them.

To make important progress, it is necessary to leave the beaten track traveled over again and again by scientific schools, and to seek some elevated standpoint outside where one can look down upon matter and its associated forces as a whole.

If we seek such a standpoint, one of our first observations will probably be that matter and force form a mysterious duality.

There is abundant evidence of force being locked up in matter, but not a single example of force isolated from matter; we may therefore almost safely assume as axioms the following propositions:—

1. As we have evidence of force being confined in matter, and never find it separated from matter, that matter is the home of force.

2. That as force cannot be separated from matter, where there is no matter there can be no force.

3. That as the existence of force involves the existence of matter wherever force is exerted through what is termed space, be it the action of the earth's magnetism on a compass needle, or the radiations from the most distant of the stars, the energy received must have been transmitted through a medium of some sort, and if the above three propositions be admitted, it follows as a corollary that our solar and stellar systems float in an ocean having properties in common with matter; but when the mind tries to grasp what must be the nature of this medium, or ether, as it has been termed, it is confronted with what seems to be an insoluble problem, for it becomes necessary to conceive the existence of imponderable matter, in other words a peculiar kind of matter in which the distinguishing characteristics of matter, viz., weight and inertia, are absent. Mathematicians seem to be able to grasp the conception of such a medium, and Sir W. Thomson has attempted to give a popular illustration of it by means of two illustrations. The first illustration assumes it to have the property of a stiff jelly, which will allow a ball inserted in it to oscillate backwards and forwards, but not to pass through, because the jelly is a solid; the second illustration assumes it to have, in a very refined degree, the properties of pitch which, though brittle and solid, possesses the property of fluidity, and will allow a denser body to pass through. Now although the phenomena of electricity and magnetism not only require for their explanation the assumption of a continuous chain of matter, but seem, also, to demonstrate as clearly as anything can be demonstrated the existence of such a chain, still it is impossible to understand the existence of a medium having positive and negative properties at one and the same time, and therefore I cannot regard the ether theory otherwise than as a sort of Athanasian creed, occupying the place it does in the absence of more complete knowledge.

When force is transmitted by a dynamo driven by a steam engine we have energy unlocked in the fire grate partly transformed in the boiler, and completely transformed in the steam engine, directly to the amount of mechanical force produced and expended in the production of electrical motion in the armature coils and conductor, and also in overcoming the magnetic inertia and maintaining the magnetic polarization of the field magnets. We see, here, there is a series of transformations before the heat energy becomes converted in electrical energy, and the fact of this series of transformations intervening has raised the doubt in my mind, which has been expressed in an earlier portion of this article, whether there is such a thing in a strictly true sense of the term as the conversion of one force into another.

There is a wonderful parallelism and harmony in all the phenomena of nature, and in this comparatively advanced period, everything produced by labor, is in a sense, a form of energy; the production of a picture, or the making, say, of a chair, involves labor, and the picture and the chair are the complement or balance of the energy expended, and which was obtained from the consumption of food; but it can be scarcely said that the picture and the chair have locked up in them any of the forces which were stored up in the food eaten. Now the chairmaker and the artist cannot directly obtain from their respective productions the energy expended in producing them, but through the convenient medium of money they can do so; and in the case of the artist, not only can he obtain stored-up energy to the amount consumed, but he can obtain a great deal more, because he is an advance on ordinary matter and possesses something approaching to creative energy. In an earlier period of the world's history, when trade was carried on by exchange and barter, the invention of money was as great an advance as the determination of the mechanical equivalent of heat in our own day, and the man who invented it was the Joule of his period, as his discovery enabled the multitudinous forms of human labor to be dealt with in terms of energy. The possession of gold gives a man energy of position, which is really the same thing as what we call storage of energy.

In the labor market, 1 lb. of gold may be said to have about thirty times the energy of the same weight of silver, and 1 lb. of silver about 100 times that of copper.

How suggestive this is of the atomic weights of the material elements which vary so much. The atomic weights are, after all, only an expression of the relationship of elementary atoms to electrical and chemical energy stated in terms of their relationship to gravity, and it was the want of harmony here shown between gravity and electrical energy in their action on matter which suggested the doubt whether gravity and electrical force could possibly be protean shapes of a common principle, and which the conversion of one form of energy into another form of energy seems to assume.

I wish now to say a few words in reference to the earth considered as a conductor, for, as shown by the correspondence which crops up from time to time in the *Electrical Review*, as well as electrical literature, the views entertained by some electricians would appear to be somewhat hazy; for example, in Culley's work, the text-book adopted by the postal telegraph department, there is the following passage:—"It was at one time imagined that the earth completed the circuit precisely in the same manner as a return wire; this opinion is now considered incorrect."

When a young man, I made the discovery, or I thought I had, that all true science could be explained by common sense reasoning, and that when a so-called scientific explanation did not harmonize with common sense, then such explanation might be suspected of being unsound. Huxley, who is happy at phrases, has expressed much the same view by describing science as disciplined common sense.

I am of opinion that Huxley's dictum is sometimes overlooked by scientists, and that the extract I have made from the text-book of the postal telegraph department is a case in point. Why should the earth be an exception to other electrical conductors. I think it may be safely asserted that although similar results are often brought about by very different methods, Nature never performs the same operation in more than one way. for example, the various types of dynamos all develop electrical energy in a similar manner, and animals and insects possessing sight see all of them through optical organs resembling one another and acted upon by light in a precisely similar way, and when the earth forms part of an electric circuit why should electricity follow another law in this part of the circuit?

In papers published 30 years since in the transactions of the institution of Civil Engineers and Society of Arts, I described among other things the relationship of the earth to the insulated wire of a telegraph circuit, and also to statical electrical phenomena.

I also described in what way submarine circuits differed from overground ones, and I called attention to what older electricians knew under the name of absorption of charge, which I said might be considered as an approach to conduction. I mention this because it has since been christened electrification, and Fleeming Jenkin credited with the discovery of it.

I pointed out what was scarcely appreciated in those days, that the tension, or as it would now be called the potential of a current, where it entered the insulated wire of a telegraph circuit would be limited by the total resistance of the circuit, and adding to the number of battery cells would not in a circuit (whose resistance was so small as to be a negligible quantity) practically increase the potential, and I stated that the earth owing to its great mass relatively to an insulated telegraph wire might be regarded as a conductor having no resistance, and consequently the potential would be infinitely small and practically the same in every part of this portion of the circuit.

I said that the prime conductor of a frictional machine formed one coating of a Leyden arrangement, the air, the dielectric and the earth the other coating, that the only difference between it and an ordinary Leyden jar was that as the surface of the earth was immensely larger than that of the prime conductor, and as the positive electricity on the one surface was balanced by an exactly equal quantity of negative electricity on the other surface, the potential on the larger surface was less than that on the smaller surface directly as their difference of area, and where as in this case the earth formed one of the coatings, the potential of the electricity accumulated on so extensive a surface was so small as to be inappreciable. I mention this because certain consequences follow from what I then pointed out which I think are not appreciated even at the present time.

In those days it was very generally considered that the transmission of currents through an underground circuit followed an

1. I assume there is no such thing in the strict sense of the term as dissipation of energy; what is termed dissipation of energy is a local dissipation only.

altogether different law from that which governed conduction in suspended circuits. I urged it was impossible to believe that nature had one law for an insulated suspended wire and another one for submerged and underground circuits; and I stated that the only difference between them was one of degree. I further stated that although the accumulation of statical charge in a suspended circuit was, when compared with that of a submerged conductor, so small as to have been generally overlooked; still it was there, and could be seen, that I had obtained very decided indications of it in a suspended wire of 60 miles in length, using an ordinary lineman's galvanometer, and that with more sensitive instruments it could undoubtedly be seen on much smaller lengths.

I pointed out that although a submarine circuit had been considered to be similar to an ordinary Leyden arrangement there was *practically* a very great difference between them. I stated that it was well understood that induction involved insulation, and that where there was no insulation there could be no statical charge, that the insulation separating the inner and outer coatings of a Leyden jar was the resistance of glass, whereas the insulation separating the inner and outer coatings of a submarine circuit considered as a Leyden arrangement was the resistance of the copper conductor only, the inner coating of the Leyden arrangement, and connected through the circuit of the telegraph instrument by a metallic conductor to the outer coating, viz. the salt water of the ocean.

Now this was quite overlooked by our leading scientific men, including Professor W. Thomson, and even Faraday, until after I had pointed out. Snow Harris had stated that induction decreased as the square of the resistance separating two conductors, but I suspected the truth of this law, for the reason that electricity was not a radiant force but a dual one, and that wherever there was free positive electricity, there must be in its neighborhood an equal amount of negative electricity, and this was irrespective of any difference of surface there might be in the two conductors between which the induction occurred, and as a result of series of experiments carried out at the time when I was writing my paper, I found induction followed the same law as conduction, decreasing between flat plates directly as the distance separating them, or, to put it in another way, if a Leyden arrangement, which we will call No. 1, be constructed of two metal plates separated by a dielectric, say $\frac{1}{10}$th of an inch thick, and a second similar arrangement be constructed with a dielectric of $\frac{2}{10}$ths of an inch, No. 1 will have twice the storage capacity of No. 2, or to state it differently, if in No. 1 arrangement 20 units of electricity were necessary to electrically charge the plates to a potential of 10, only 10 units of electricity would be required to raise No. 2 to the same degree of potential.

There is another experiment I tried at this period, and repeated more carefully a few years later. I mounted on a cylinder of annealed soft iron, 6 inches long and ½ inch in diameter, two wooden discs about 6½ inches in diameter. I then wrapped two layers of No. 18 B.W.G. insulated copper wire immediately on the iron core, counting the number of convolutions; after this I wrapped the bobbin with string to a diameter of 6 inches, and outside the string I wrapped two layers of the No. 18 wire, counting the number of turns, so as to be sure there was the same number of convolutions in each set. The length of the insulated wire of the outer convolutions was approximately 12 times that of the convolutions of smaller diameter; and the mean distance of the outer convolutions from the centre of the iron core was approximately 12 times that of those wrapped immediately upon it.

I joined the convolutions of insulated wire in series, but so connected them that the electricity circulated when the battery circuit was closed in opposite directions through the two sets, and I found when I closed the circuit, there was not the slightest trace of magnetism produced, thus showing that an electric current flowing through a circuit whose length was 12 and whose distance from the centre of the iron core was 12, had the same magnetizing influence as a conductor whose length was 1 and whose distance from the centre of the iron core was 1 also.

I wish now to point out certain consequences arising out of these experiments, but these must be deferred to the continuation of this article in next week's *Review*.

(*To be continued.*)

.... DOGMAS have their use undoubtedly, and the phrase, " heat is a mode of motion," shines with a reflected glory, simply because some of our most eminent scientists have been content to accept the dogma as a rallying point or flag; and it is the work they have accomplished fighting under this banner, and this work *only*, which has given a value to the phrase, much in the same way as that given to the tattered rag some distinguished regiment carries into battle, and around which men fight and die, and which in the end finds deservedly a resting place in our cathedrals, because it symbolizes that which distinguishes men among men, and man as man from the greater part of creation.—*S. A. Varley.*

ABSTRACTS AND EXTRACTS.

BLOCK SIGNALS.

THE following letter on Block Signals on American Railroads, appeared in the *Railroad Gazette*, for August 24. We append the editorial comments from the same number of that journal.

To the Editor of the Railroad Gazette:—

The expense incurred by railroads operated under the block system would naturally lead to the conclusion that it was an additional safeguard against accident. But with an experience of more than 10 years in train service as freight and passenger brakeman and conductor on roads so operated, I claim that the facts do not sustain the theory. I have yet to learn how the system will prevent an accident, while, on the contrary, I can recall many instances when it has been the cause, indirectly if you choose, of rear end collisions. Advocates of the system will claim that it is owing to neglect of positive orders by the trainmen that makes a rear collision possible. That I concede, and it is my objection to the system that it will make the most careful flagmen and conductors careless. It offers a premium on negligence. It makes trainmen negligent in the discharge of positive orders, less sensitive to danger and the necessity of protecting themselves against following trains. The responsibility of protection is, in the face of positive orders to the contrary, divided between the train crew and the operator, or block. Trainmen do and will rely on it for protection, any rules to the contrary notwithstanding. If two trains were not permitted on the same block, and no clearance orders given contrary to the indications of the semaphore; and if enginemen of following trains were informed that they must rely solely upon the block, as no flagman from the preceding train would be sent back to protect it, the system would accomplish the result intended.

Observe the movement of the rear brakeman on the Central of New Jersey when his train slows up to make an unusual stop. If he is where he has not an unobstructed view in the rear of his train, he is off, and back with a flag before his train comes to a stand still. Do you note the same vigilance on a road operated under the block system? My experience is that the brakeman there usually wants to find out what the trouble is; wonders how long they will be detained, and if he goes back at all, it is a very short distance, and then only after the train has stood 5 or 10 minutes. Running close behind him is an extra train, or a delayed passenger train, anxious to make up as much lost time as possible. The engineman arrives at A, is stopped by the block and informed that train No. — has not cleared B at the time he receives his order; that he may go on, but must run cautiously. But away he goes at schedule speed if not faster. He is behind time, he has the opportunity, and desires to make a good run—all enginemen do. The passengers demand it, and the officials require it of him. He reasons that he is perfectly safe in maintaining a high rate of speed, because if the preceding train has not cleared B it will have a flag out far enough behind to stop him. That is where the system invites disaster. If he knew that no flagman would be sent out from the train ahead he would not hit it. He would " run and look," prepared to stop within a train length where the view ahead was obstructed.

The most extensive system operated under the block did not have a rear collision during the Centennial in 1876, and its passenger business was enormous. It placed on its passenger trains its most reliable freight conductors and brakemen, and it was due to their vigilance, and not to the block (which was then a new thing there), that they were so free from accident. Just at the close of the heavy traffic, a local train in charge of conductor Thomas Gallagher, ran into a freight at Linden, and a few days afterward he ran into another freight that was pulling into a siding at Menlo Park. Both accidents were indirectly caused by the block system.

Quite recently I went into the office at A and reported my train clear of main track on a siding, half a mile south of the station. The operator looked at his train-sheet and replied: "I have you reported clear at B, at —, " stating time. I had not been south of switch when my train was side-tracked, and B was four miles beyond it.

I have asked hundreds of railroad men their opinion of the system, and I have yet to hear the first conductor, engineer, despatcher, or any man directly connected with train service, say a word in its favor.

LANGDON.

[EDITORIAL.—*Railroad Gazette.*]

WE print in another column a letter from a trainman concerning the practice of some American roads in block signaling. We publish this letter because it is not merely the opinion of a freight conductor, but is also a good representation of the views held by many intelligent superintendents. Notwithstanding the widespread use of, and faith in, the principles of block signaling, there is a strong sentiment in various quarters that there are good arguments on the other side. These arguments are not often formulated, but the feeling exists, nevertheless. This letter constitutes a strong expression of what may be called the Jersey Central senti-

ment; the conviction that, with wide-awake trainmen, fully alert to their duties, train running can be carried on better without block signals than with.

The primary object of block signaling is often lost sight of. It is not to be denied that in clear weather, by daylight, and with young and lively men, trains can be run on thousands of miles of railroad, for scores of years to come, with substantial safety and without block signals. But the very first reason for adopting block signals years ago, and the most important reason demanding their adoption now, is the fact that trains must be run when the weather is not clear, when the darkness is thick enough to be felt, through tunnels full of smoke and with men who will sometimes be negligent. Every one recognizes that under certain conditions, traffic will be more or less delayed by the use of the block system. Last year's collision at Hexthorpe, England, where 19 people were killed, is a melancholy illustration of the strong influence which this idea exercises over the minds of otherwise cautious railroad men. An immense traffic was imperiled and was actually involved in disaster because the delays necessary for safety were deemed unendurable. The theory of men like our correspondent doubtless is that the block system may be useful at night and during stormy weather, but that we should work without it when the weather and other conditions are favorable. But by a moment's reflection we see that any such partial or intermittent use of the system will bring in more dangers than it will cure. If we are to have the benefit of the principle at any time, we should employ it systematically at all times, and put up with the incidental inconveniences. Conditions of this kind have to be submitted to in other departments of business and are recognized as based on just principles. Book-keepers every day make hundreds of figures which would be unnecessary, and a waste of time, except for the necessity of following an inflexible system. "Langdon's" way of running trains recognizes this principle by making strict rules about going back with a flag when the brakeman is morally certain that no train is following.

The use of permissive blocking, which is the basis of the illogical system complained of by "Langdon," and which is quite prevalent in England as well as in this country, cannot be regarded otherwise than as an evil. It may be admissible as a lesser evil, but it should be clearly understood that its faults are not chargeable against a scientific block system. It brings in just the train of doubtful conditions described in this letter, and neutralizes much of the good effect of an otherwise almost perfect system. The reason why "Langdon's" experience of 10 years and the opinions of the hundred men he has talked with are against the system is found in the existence of this loophole. Telling an engineman to run cautiously, and telling a flagman to go back with red signals when he knows that his going back will almost certainly be unnecessary, constitute one of the most troublesome combinations in railroad practice. The absolute block system in perfection entirely obviates "going back to flag." The old plan makes flagging of vital importance. Permissive blocking mixes the two, and while perhaps preventing some rear collisions, certainly leaves the door open for one large class, those which occur from careless handling of trains when it is known that other trains are near. The essence of permissive blocking is to run with caution; but most rear collisions occur when the runner is using some caution, not when he is "humming along" at full speed. Railroad men who argue against the block system are prone to pass lightly over the objections brought against *their* system as regards its suitability for a heavy traffic where tunnels are numerous, fogs frequent and night trains heavy. But passengers now-a-days want to ride as promptly, as fast and as safely when the engineer can not see the chimney of his own engine, as when he can see three miles ahead.

The statement that officers demand fast running by engineers when it is not safe to run fast, is undoubtedly practically true in many cases. As in the case of men sent out with money to influence a legislature, the injunction is to do nothing wrong, but the person enjoined unmistakably understands that he must achieve success. The mistake of an operator which has recently come under "Langdon's" observation shows the value of electric locking for block signals.

PROTECTION FROM LIGHTNING.[1]

THE present season of thunderstorms brings the question of protection from lightning into special prominence. It is a matter in which every one is interested, for the electric fluid is no respecter of persons, and strikes both at the hut and the palace, while it does not always spare the lonely wayfarer plodding along the road far from buildings of all kinds. It is, however, high and isolated edifices that suffer from it most; churches, factories, farm-houses and country mansions are specially liable to its attacks. There are, however, now very few of these not furnished with conductors which are presumed to afford complete protection. Usually they do, but still it is by no means uncommon to hear of the lightning leaving a stout conductor to play vagaries within the building, springing hither and thither, and leaving most unpleasant footmarks wherever it alights. Until very recently it was customary to assume that the lightning conductor was in fault when such an unexpected result was realized. Either the joints were bad or the "earth" was deficient. Among rods of early date the latter was very often true, for they sometimes penetrated but a very short distance into the soil, or ended in a stratum which became perfectly dry during the hot months of summer. But when every allowance has been made for such imperfections in construction and erection, there still remain many cases of failure which are not easy to explain without recourse to researches which have been made public during the last few years, and which tend to weaken our faith in the theories regarding protection from lightning which were current only a very short time ago. When electric self-induction began to be studied by practical men, it was seen that it must have a great bearing on the conditions under which a flash of lightning can pass along a conductor. The question of a more or less perfect earth loses much of its importance in the face of a counter electromotive force of thousands of volts suddenly generated in the rod, and opposing the quiet passage of the lightning. It only lasts the minutest fraction of a second, but then lightning cannot brook any delay, and it will strike out from the rod in gushes at any place where a neighboring conductor offers it an alternative path, often traversing a foot or two of air, or piercing a brick wall in its attempt to escape. For purposes of analogy we may compare the effect of self-induction to that of inertia, to which it bears a great similarity. The rod is full of quiescent electricity, when suddenly the lightning starts from the clouds, and with one mad spring through half a mile of sky, it enters the conductor, seeking to rush through it to the ground. But to do this it must set in motion the electricity with which the rod is already filled. The effect is like a piston coming down on a mass of water in a steam cylinder; an enormous pressure is set up, and the fluid seeks every avenue of escape, spurting through joints and stuffing-box, and sometimes carrying the solid iron of the cylinder cover with it. In the same way the electricity will often dart out from the rod, even though the lower end may make most excellent contact with the soil. The self-induction in the conductor is too great to permit of the electromotive force of the discharge falling immediately to a safe limit; it is, no doubt, immensely decreased, for after a flash has traversed half a mile of sky a few feet of air is but a small matter.

The difficulty of getting an electric discharge to traverse a metallic conductor has been demonstrated by Dr. Oliver Lodge in a very simple but convincing manner. He takes two Leyden jars and connects their inner coats respectively to the two terminals of a Voss machine. Between the outer coats there are practically three paths along which electricity can travel, namely, the table on which they stand, an adjustable air gap between a pair of discharging balls, and an insulated wire. The table forms an imperfect conductor between the jars and the ground, while the insulated wire guarantees that the jars shall remain at the same potential. There are also a pair of adjustable discharging rods between the terminals of the machine. Now, when the machine is worked the electricity accumulates in the jars, and while it is doing so the outer coatings remain at the same potential, there being no current in the wire connecting them, and no tendency to spark at the air gap. The tension in the jars, however, rises until it is able to leap across the space between the terminals of the machine, whereupon there is an instant rush of electricity between the outer coatings. There is practically no path for it along the table, and hence, it must go along the conductor, or across the air gap, or by both paths. Now, as the resistance of air is millions of times greater than that of metal, we might, at first sight, assume that there could be no spark between the terminals. But Dr. Lodge shows that when the conductor consists of 40 ft. of No. 1 (B. W. G.) copper wire, the discharge will as easily leap across a space of 14.3 tenths of an inch as take the easy path open to it. The effect of the self-induction is to raise the natural resistance of the wire from .025 ohms to something which is comparable with 1½ in. of air. If the copper wire be replaced by a similar length of thin iron wire (No. 27) having a resistance of 33.3 ohms, a still more unexpected result is obtained. The resistance of the metallic circuit is now 1,300 times as great as before, but instead of the discharge being able to leap a wider gap it can only bridge 10.8 tenths of an inch of air. If the continuous circuit be made through a capillary tube of liquid having a resistance of some 300,000 ohms, the spark length increases to 16 or 17 tenths.

We do not, however, need to employ even the very simple apparatus described above to demonstrate the tendency of an electric discharge to flash out sideways. If we take a yard of the thinnest platinum wire obtainable, and place it parallel to a thick copper rod, the ends of the wire being bent towards the rod until they approach it within a sixteenth of an inch, then, when the discharge from a Leyden jar is sent through the rod, it will be found that a part will leave it for the attenuated parallel path, leaping the air gap to reach it. The publication of Dr. Lodge's experiments has drawn attention to certain researches upon lightning discharges for protecting telegraph instruments carried

1. *Engineering* (London).

out in 1864 by Professors Hughes and Guillemin. The results of the earlier trials are in substantial agreement with those of the later ones, except as regards the superiority of iron over copper as a conductor. It was found that no discharger would protect the coils of the instruments if a very powerful discharge from a large battery of Leyden jars was sent through it, and that if the discharger were replaced by a copper rod of 1 centimeter in diameter, sufficient electricity passed by way of the instruments to burn a fine iron wire. When, however, the wire was replaced by a flat plate, even of tinfoil, a very large measure of protection was obtained. We thus see that ordinary measurements of resistance applied to lightning conductors may be very misleading if other conditions are not taken into consideration.

When the existence and the effects of self-induction are appreciated it is easy to point out the means to minimize the latter. Clerk-Maxwell showed that "the electromotive force arising from the induction of a current on itself is different in different parts of the section of the wire, being in general a function of the distance from the axis of the wire as well as time." Professor Hughes has also experimentally investigated the comparative effect of disposing the metal of a conductor in different ways. He found that self-induction is reduced 80 per cent. in iron and 35 per cent. in copper by using the metal in the form of a flat strip or ribbon instead of in a cylindrical wire, and that if the ribbon were divided longitudinally into bands, and these were placed a little distance apart, the self-induction was still further reduced. He therefore recommended the use of copper strips for lightning rods. Dr. Lodge has also pursued the same line of investigations, using, however, the discharge from a Leyden jar, as more nearly resembling lightning than the interrupted currents of Professor Hughes. He proved, using the apparatus referred to above, that if a copper wire of given weight and length were employed to connect the jars, then when the air gap measured 8.86 millimeters the discharge would sometimes take place by the wire and sometimes through the air. If a ribbon conductor of the same weight and length were substituted for the wire then the air gap must be reduced to 6.25 millimeters before the same conditions were attained, thus showing that the ribbon presented an easier path for the discharge than the wire, although the metallic resistance of the two was equal. Dr. Lodge's experiments also seem to show that iron is quite as advantageous as copper as a material for lightning conductors, and he goes as far as to say that he considers the use of copper as doomed. It is well known that iron has far more self-induction than copper when tested in the ordinary way, and hence it offers a greater "impedance" to the passage of a current than the other metal. But when the discharge from a Leyden jar is substituted for the interrupted current then a result is obtained which suggests the explanation that the magnetic qualities of iron have not time to come into play during the passage of the discharge.

Now in what way are the experimental data we have mentioned to be applied in practice? Shall we abandon our accustomed plan of seeing that the joints of the conductor are well and securely made, and cease to care whether the "earth" offers a great resistance or not? He would be a bold man, we think, who would venture to do this. The utility of the old plan has been proved in so many thousands of instances that it would be most foolish to abandon it on the strength of laboratory experiments. A Leyden jar is not a thunder cloud, and it is quite possible that its discharge does not exactly simulate the effects of lightning. But it would be equally unwise to neglect the latest teaching of science, for although lightning conductors generally serve the purpose for which they are designed, there is still a long list of unexplained failures which disturbs our faith in their efficiency. The safe course seems to be to graft the new principles on the old practice. Let us abandon the old cylindrical rod for the flat tape, or, better still, for a number of tapes or small wires led down different parts of the building, so that they may be beyond the sphere of each other's influence. Another point of importance is to provide plenty of electrostatic capacity for the reception of the flash, and thus to keep the electric tension moderate. Professors Hughes and Guillemin found that if they substituted a large condenser for their lightning discharger the result was far better. A splendid example of the protective power of an extensive metallic surface came to light in 1873, when the conductors of St. Paul's Cathedral were overhauled. It was found that the original conductors which had been erected for the protection of the dome had been cut through in the course of some alterations, and partly removed. The lead covering was absolutely insulated from the ground, and had been for some years. During that time it is certain that it must have been the recipient of many lightning flashes, yet it had never suffered any injury. It had taken them all in like the coating of a Leyden jar receives the output of a machine, and had held them until they leaked away down the wetted stonework, and thus gradually got away to earth. Unfortunately, leaden roofs are not very common in modern buildings, but where they exist they should be connected to the conductor at several points. This latter precaution is to avoid the destructive effects of the surging of the electricity which seems to take place after a flash, and it is of great importance. We have not, however, the space to enlarge on that point at present, but shall probably return to it in an early issue. For the present we must confine ourselves to the points mentioned above, with the addition of a caution against undue elevation of the point of a conductor. A lightning flash is too dangerous a visitor to be invited. Ample preparations must be made for its reception; but still its visit is not desirable, however hurried it may be.

VON HEFNER ALTENECK'S AMYL ACETATE STANDARD OF LIGHT.

The author has investigated the effects of changing the dimensions of various parts of the lamp from the normal values as settled by the inventor. An important point in the constancy of the standard is the height of the flame; and the following table shows the results obtained by altering the height from the normal height of forty millimeters:—

Height of flame.	*Illuminating power. Standard candles.*
20 mm.	0.38
25 "	0.55
30 "	0.70
35 "	0.85
40 "	1.00
45 "	1.12
50 "	1.25
60 "	1 50

Increasing or decreasing the diameter of the wick tube by two millimeters at a time diminishes the light by one per cent.; so that the dimensions chosen by Von Hefner Alteneck gave the maximum of light. An alteration of the portion of the wick tube which rises above the body of the lamp by one millimeter, makes a difference of 0.2 per cent. in the light.

In the old form of the amyl acetate lamp the height of the flame is gauged by a sight carried on the top of a small rod fitting into the body of the lamp. Dr. Liebenthal has introduced an improvement on this arrangement. The lamp is provided on one side with a vertical screen, the upper edge of which carries a small camera; the lens is turned towards the flame, and has such a focal length that the image of the tip of the flame is seen clearly on the disc of white alabaster glass which forms the back of the camera; by means of a scale on the glass the exact height of the tip of the flame can be read in millimeters, the middle division corresponding to forty millimeters.—*Elektro-technische Zeitschrift.*

CORRESPONDENCE.

NEW YORK AND VICINITY.

The Board of Electrical Control.—Dangers of the Elevated Railroad.—Electric Traction on Fourth Avenue.—Rival "Ticker" Interests in Court.—The Telegraphers' Mutual Benefit Association.—Lecture by Dr. Wheeler on Electricity.—Opening Meeting of the American Institute of Electrical Engineers.

Recent meetings of the board of electrical control, indicate that the proper regulation of the overhead lines is becoming a matter of apparently more importance than the question of placing them immediately underground, which is now generally understood to be a work of considerable magnitude. There have been a good many permits issued for the erection of new poles in order that contracts for the lighting of streets could be carried out. Under one of these, the Mount Morris company has constructed a new line from Harlem to Washington Market. None of the arc lighting lines in the city are, however, up to the standard which will warrant the board in granting certificates of inspection as required by the rule adopted July 2d, which is for the time being inoperative. At the meeting of September 18th, a new rule was adopted upon recommendation of Dr. Wheeler, fixing the height of out-door lamps at nine feet and in-door lamps at eight feet. A small sample of underground conductor was presented to the board for approval which was to be placed in the Sixth avenue conduit by the East River Electric Light Co. It was decided that it was not within the province of the board to determine in advance whether such a a conductor was suitable, but that it was the duty of the manufacturer to ascertain the requirements and govern themselves accordingly. The electrical expert would make the necessary tests after the conductors were placed in position and if they did not come up to the standard they must be removed at the expense of the contractor, and consequently electrical companies should see that they were protected against the possibility of inferior insulation in their agreement with the manufacturer. The inspection of overhead lines has now been going on for over two months and about 15 per cent. of the defects reported have been remedied, but it will be some time before the lines are in good condition on account of the great extent of territory which they cover. An electric light wire fell across 28th

street, one rainy night last week, and a passing cab horse stepped on it and was thrown down. No damage was caused however.

It would not be out of the way, if a board of control was appointed to look after the dangers of the overhead railroads as well. An iron shoe, weighing 14 pounds, fell from one of the trains in the Bowery near Grand street, a few nights ago and scraped the person of Steve Brodie sufficiently close to tear his trousers. It was a narrow escape, and he was not injured in the least.

The beginning of regular trips by the new electric motor cars on the Fourth avenue railroad is considered quite an important event in the march of improvment. These cars are operated by the Julien storage battery, and they have been built expressly for this service. The most radical departure in the construction of the car itself is the use of double trucks. It is to be hoped that their operation will be sufficiently successful to lead to a reconsideration of the determination of the Third avenue people to introduce the cable system on that line.

The Kiernan News Co. has been again in court. This time an attempt was made to secure a continuation of the injunction against the Stock Quotation Co. for purloining news from the tape of the Kiernan "ticker." The evidence was secured in the usual manner of fabricating bogus despatches which were at once copied, so it was claimed by the rival concern. Judge Barrett, of the Supreme Court, refused to grant the motion because the evidence was conflicting. It is said that the Stock Quotation Co. was about to bring a similar suit against Kiernan.

The annual meeting of the Telegraphers' Mutual Benefit Association, will be held in this city, at the Western Union building, on Wednesday, November 21st. There are several proposed amendments to the constitution and by-laws to be acted upon, among them being a proposition to add a medical director to the board of officers, whose duties will be to pass upon all applications for membership. Medical examinations have been insisted upon heretofore, but the examiner was not a regular officer of the association as is now contemplated. This association is now one of the oldest and most important of its class, and its statistics are therefore of great value for the guidance of other organizations. It has already passed through one serious epidemic of yellow fever successfully, and will no doubt succeed in doing so again as its surplus is ample to guard against any probable loss which would impair its stability.

The Young Men's Christian Association has arranged a very interesting series of "Practical Talks by Practical Man," for the month of October. The first will occur on Friday, October 5th, when Dr. Schuyler S. Wheeler, of the Board of Electrical Control will talk about the modern applications of electricity. He will be assisted by Mr. Francis B. Crocker, and the lecture will be copiously illustrated.

The American Institute of Electrical Engineers, will hold the first meeting of the season on October 9th, when Mr. Frank J. Sprague's paper on "Municipal Rapid Transit" will be discussed. The paper was read June 19th, and published in the August number of the ELECTRICAL ENGINEER. On account of its length and the importance of the subject it was deemed proper to defer the discussion until the opening of the next season. Those who are not members of the Institute but desire to be present, may obtain admission cards by addressing the secretary, Ralph W. Pope, No. 5 Beekman street, New York.

The position taken by the United States Illuminating Co. with regard to subways has brought about considerable feeling between that company and the Board of Electrical Control. Upon the 21st of September some workmen, employed by the Bureau of Encumbrances, engaged in removing a line of poles along Sixth avenue, found it necessary, in order to remove the pole at the southwest corner of Sixth avenue and Thirty-sixth street, to cut one of the circuits belonging to the United States Illuminating Co., which supplies current for nearly 50 arc lights for private use. An inspector of the United States Illuminating Co. consented to cut the wire, upon the express understanding, so he states, that they be allowed to connect the wires as before, as soon as the pole was removed.

The wire was cut and the pole removed, and then the linemen of the electric light company attempted to join the severed wire. Here, it is claimed, the subway commissioners, through their subordinates, stepped in and forbade the proceeding, urging that, under existing law, no electric lighting company could, under any circumstances, repair or alter old or stretch new wires on poles in this city. Their employés could only climb the poles for the purpose of taking down the wires and placing them underground.

A policeman was stationed upon guard to prevent any interference with the wires. The various patrons along Broadway and Sixth avenue, to the number of fifty, are deprived of electric lights, much to their indignation.

President Lynch thus concludes his version of the affair: —

"Now, whatever the rights of the Board of Electrical Control in this particular case may eventually prove to be, Friday's proceeding was, to say the least, a breach of good faith on its part, and an exhibition of petty annoyance unworthy and undignified on the part of any body claiming to derive its authority from the State of New York."

On the other hand, the subway commissioners claim that the electric lighting concern cut its wire at the request of the Bureau of Encumbrances and not at their instance. President Hess said that subways had been provided for the carrying of all electric wires underground, and that the United States Illuminating Co. was the only concern of the kind that refused to obey orders to bury its wires. Secretary Morse declared that had Mayor Hewitt given the subway commissioners proper support there would not be a wire above ground up-town.

NEW YORK, September 28, 1888.

PHILADELPHIA.

The Meter to be Used by the Edison Company in Philadelphia.—Camden Streets may be left in Darkness.—The Gas Company Obstructing Electric Lighting.—Trouble over the Tearing up of Sidewalks by the Telephone Co.—The Thomson-Houston Company demands Royalty from the Electric Light Co., at Carlisle, Pa., on its Regulator Patent.

THE use of meters in electric lighting is comparatively new to Philadelphia. "We will introduce the meter here when we get our new station on Sansom street in operation," said Mr. Kepler, one of the agents for the Edison system, recently. "It is what is called a weight meter, and works perfectly. It will be used in all establishments where we furnish the lighting, and will show just how much electricity is used. Such a thing is absolutely necessary for our protection, for people are apt to be extravagant in the use of electric lights and let them burn much more than they would gas, as they give out no heat and cause no inconvenience in any way. If we were to make contracts to supply just so many lights to storekeepers and others we could not tell how much electricity would be used, but you may be sure that the lights would be burned much more than there was any necessity for.

"The accuracy of the meters is shown by the fact that the Edison company has about 1,800 customers in New York city, and only one of them has been dissatisfied with the readings of the meter. Drexel, Morgan & Co. kept a private record for months of the length of time their lights burned, and the amount of electricity used, as estimated by their figures, varied only three per cent. from the statement in the bill of the Edison company, and the difference was in favor of the meter."

The possibility of darkness for an uncertain length of time in all but five streets stares Camden, N. J. (across the Delaware from Philadelphia) in the face. The gas company maintains a defiant attitude and refuses to sign a contract to furnish gas for the street lamps unless the lighting committee of city council shall restrict the number of electric lamps to 36. The gas company's old contract expired on July 1, but it has since been supplying the city under its provision until a new contract can be awarded.

The members of the city council lighting committee, it seems, have an idea that they were elected to serve the people, and take tight hold of the horns of the dilemma.

City-solicitor J. Willard Morgan had drafted the contracts for the two lighting companies, and had them ready for the signatures of the proper officers, and when the committee met at the City Hall, the documents were yet unsigned. A number of citizens had gathered to watch the proceedings, and they took a great deal of interest in what transpired. The solicitor read the long documents, while the members of the committee listened attentively. At the conclusion of the reading there was a spell of deep silence. Then it was stated that the gas company representatives objected to signing the contract prepared for them because there was in it no stipulation that the number of electric lights should be restricted to 36, as that was the number decided upon by the committee, and there would be no money in the contract for the company at its bid of $25 per year for each gas lamp if the number of electric lights should be increased beyond 36.

"I know of nothing in the records of the committee of council," said chairman Dorell, "showing that the number of electric lights was to be restricted to 36. The chair will entertain a motion to approve the contracts as drawn by the solicitor."

Mr. Roberts then, with a little amendment tacked on by Mr. Rex, moved that the committee approve the contract as being in accordance with the committee's report on the matter submitted to and approved by the last meeting of city council. The motion was adopted without a dissenting voice, and Mr. Roberts immediately broke in with a motion to place arc lights at five other street crossings not lighted at present. This was followed by a motion of chairman Dorell for six lamps on Broadway, below Kaighn avenue, and Mr. Stone for three lights on Mount Vernon street below Sixth—and all were passed. These additions will make 50 lights in all in the city, and there is a disposition on the part of the committee to still further increase the number, as the aggregate cost is no greater than for gas. After the committee adjourned chairman Dorell and superintendent Mullen, of the electric company, made a tour of the streets to designate the gas lamps to be extinguished. If the gas company should, in the meantime, endeavor to strengthen its position by refusing to light the lamps the city will be in a predicament.

"A high-handed outrage," is what the residents and property-owners on Cherry street, between Third and Fourth, term the recent action on the part of the Bell telephone company in tearing up the sidewalk to lay wires under the street. The business men are in a state of indignation. A gang of 50 men, armed with picks and shovels, marched up to the place and began ripping up the sidewalk right and left. In less than half an hour the sidewalk, from No. 300 to No. 317, had been torn up. Hewey Eaton, whose place of business is at No. 307, remonstrated against the proceeding, but the foreman would give him no satisfaction. He hurried off to consult his lawyer and secure an injunction, but when he returned the pipes containing the wires had been laid and the sidewalk replaced. The telephone company is said to hold a permit for the work from director Wagner and chief McDonald, of the Highway Department, but it is doubted if it was intended they should use the sidewalk. The men whose sidewalks have been torn up are desirous of excavating the ground under the pavements for various purposes, but the laying of the wires will interfere with this work.

Counselor Moore says that the telephone company is liable for damages through its action, and that it did not consult the proper authorities regarding the permit for the work.

Three months ago, Carlisle, Pa., was first illuminated by electric lights by the American electric light system. The dynamos used have automatic regulators.

The Thomson-Houston Electric Co., claim under the recent decision at Boston—that the Carlisle company infringes their regulator patent, and if a royalty is not paid, a suit for damages will be instituted against the Carlisle Electric Light Co. The latter company, however, have retained $5,000 of the purchase money of the plant, and this sum will more than cover the amount of damages claimed by the Thomson-Houston company.

PHILADELPHIA, September 17, 1888.

BOSTON.

The Boston Fire Department and its Work for the Past Year.—Output of Telephones by the American Bell Co.—The Attempt to Regulate Telephone Charges Postponed by Common Council.—The American Bell Telephone Co. to Erect an Office Building.—The West End Railway Co. before the Boston Aldermen.—Hearing on their Petition for leave to Construct Overhead and Conduit Lines for Electric Cars.—Remonstrance against Overhead Wires.

THE work of the Boston fire department for the last year is of much interest. The figures given tell a story of steady progress in the fire-alarm department. Considerable advance has been made in substituting keyless doors for the old kind, and in time they will be in use in all parts of the city. During the severe storms of last winter, which proved so damaging to various branches of electrical service, the fire-alarm wires suffered but little, and no troubles were experienced that a few hours work did not remedy. The system is well in hand, and great care has been exercised to prevent the department from being left helpless in case of possible emergencies.

The city is divided into 10 fire districts. Every box in the city now gives its signals automatically to all the department houses where the box gongs are located. The box gong service has been still further extended and improved by the introduction and use of registers, placed in connection with the box gongs and operated by them, by which a record is made on a paper tape of all alarms received. There are 65 telephones in use by the department at the present time.

A general reconstruction of the wires running to Charlestown and East Boston, has been made, beginning at the Fitchburg depot, and continuing along the route of the bridges, ending at Meridian street.

The poles on Warren bridge have been abandoned, and a 19-wired cable, 1,000 feet in length, has been laid in a conduit across the same.

A sub-marine cable has also been placed at the draw of this bridge, and another at Meridian street.

Thirty-nine new signal boxes have been added to the service during the year.

Two new switch-boards, of elegant design and construction, have been provided for telephone service. They are mounted on black walnut desks which were made for the purpose, and are in use, one at headquarters and the other in the office of the chief engineer.

The usual incidental work of repairs and improvement in construction has been carried on at various points, embracing the renewal of old wire wherever required, and the extension of circuits to connect with new boxes and department apparatus.

Material has been used as follows :—42 miles No. 9 iron wire ; 5½ miles No. 12 copper wire ; 5,800 feet kerite wire ; 220 pounds cotton insulated wire ; 6,500 feet lumber ; 2,050 glass insulators ; 1,500 insulator bolts ; 1,200 lag screws ; 50 poles.

The following are the statistics relating to alarms and fires ; during the year there were 975 alarms in a population of 362,000.

Total number of actual fires	820
Confined to one building	669
Extended to others	25
Wharves, vessels, grass, etc	126
BUILDINGS.	
Slightly damaged	501
Considerably damaged	81
Totally destroyed	31
Not damaged	124

Electric light wires are charged with causing 9 fires ; kerosene in lamps and stoves runs up a bill of 78 fires ; gas and its uses caused 22 fires. The commissioners deplore the fact that the city is "provincial and unachronistic" in having a combination of permanent "call" men.

Nearly 20 call men, 57 years of age, or over, have been retired, and also several permanent men, the latter having served over 15 years in the permanent service, receiving pensions equal to one-third the salaries which they received at retirement.

All of the public clocks, 37 in number, are taken care of by the fire department.

A constant watch is kept at the headquarters, City Hall, night and day, by the operators. Each operator has assigned to him certain hours of duty, during which time he is responsible for the correct working of the apparatus in giving alarms, and all testing of the circuits and other details pertaining to the service. An automatic arrangement is connected with the receiving apparatus, by which assistance may be called from the sleeping apartments, if at any time the operator should be suddenly incapacitated by illness from performing his duties. No operator is permitted to sleep during his watch, unless expressly relieved by some one else, and by consent of the superintendent.

Each operator is accountable to the superintendent for any mistakes that may occur at the office during his hours of duty.

An accurate account is kept of the time of giving each alarm, and of the station from which it originates, and all other necessary information.

There are 400 fire-alarm boxes, divided as follows, viz.:—

Boston	122
South Boston	40
East Boston	33
Roxbury	59
Dorchester	52
Charlestown	37
West Roxbury	32
Brighton	24
Chelsea	1
	400

Thirty-seven of the boxes are private property.

The statement of the output of telephones by the American Bell company for the month ended August 20, and the fiscal year to date is as follows :—

Increase.	1888.	1887.	Increase.
Gross output	3,694	3,533	161
Instruments returned	1,760	3,353	*1,593
Net output	1,934	180	1,754
Dec. 21 to Aug. 20—			
Gross output	37,740	36,541	1,199
Instruments returned	14,646	17,663	*3,017
Net output	23,094	18,878	4,216

*Decrease.

At a meeting of the common councilmen on the 12th, an order was offered for the appointment of a joint special committee, to consist of five members of the common council, with such as the board of aldermen may join, to investigate the question of telephone charges. A motion to indefinitely postpone prevailed by a vote of 40 yeas to 18 nays.

The matters in court, in which the American Bell Telephone Co. is concerned just at present, are: the appeal from Judge Colt's decision, given in Boston (relative to the power of the attorney-general to bring suit to annul the Bell patent) to be heard in Washington, October 11, next ;—and the hearing for preliminary injunction against the Cushman Telephone and Service Co., October 4, next, at Chicago. The Bell company now have a restraining order from Judge Blodgett, restraining the Cushman company from commencing any new telephone business, until the decision on the injunction suit is rendered—which ties them up securely. It was their intention to sell out to a new company against whom the restraining order had not been issued, but this too was prevented by the same order.

The American Bell company have purchased a large lot of land on the southeast corner of Milk and Oliver streets, and their architect, Mr. Fehmer, is now preparing the plans for a fine building, every modern improvement will be introduced, and the building will be worthy of the great business to be housed in it. It is expected that the Boston exchange of the New England Telephone Co. will be removed to the new building, and a large conduit from the street is arranged for to admit cables. The distance from the present quarters is but one block, in an easterly direction.

At a meeting of the board of aldermen on the 28th ult., the matter of electric tramways came up.

The fact that a hearing was to be given on the petition of the West End Railroad for leave to introduce an electric system attracted a large number who are never seen at meetings of the board except on extraordinary occasions, and there was considerable opposition to the project. Mr. Henry D. Hyde, on behalf of the company, explained the systems, overhead and conduit, that it is proposed to use, and said that no new locations are asked for. The poles are to be erected on each side of the street, 250 feet apart. The company has been granted the right for overhead wires in Brookline, and now asks for a continuation of that system down Beacon street, West Chester Park and Boylston street to Hereford street at the new bridge, where the conduit system will begin.

Mr. Waldo Adams, owning property on Boylston street, objected to any overhead system as likely to decrease by its wires the value of that property. He would not object to a conduit system.

Councilman Frank Morison, representing Charles F. Adams, Hollis Hunnewell and other property owners on the Back Bay, objected to an overhead system as likely to disfigure the handsomest streets in the city, to say nothing of the danger to horses and pedestrians from the breaking of uninsulated wires. He thought an electric railway a good thing, but that a conduit system is the only way to run it in the city proper. He thought, further, that now is the time to make a stand against overhead wires.

Mr. Louis Curtis, an owner of property on Beacon street, objected on the same grounds as Mr. Morison. Colonel Henry Lee also opposed the mode of introducing the system, and thought wires should not come farther into the city than the forks of the roads on Beacon street. He thought the posts and wires would be an eyesore as well as a source of danger.

Messrs. F. V. Parker, Gamaliel Bradford, and others, also remonstrated, and then Mr. Samuel Hano said that he owned a half million feet of land on the proposed line, and thought that the proposed system would be a good thing. One wire was very little obstruction. He had no objection to a conduit, of course, but did not want to hinder the construction of the line in any way. Mr. Horace W. Jordan, an owner of property in Brighton, urged that the rights asked for be granted in the interests of outlying property.

Mr. Hyde, in answer to Mr. Morison, said that the conduit took longer to build than the overhead system. Rapid transit is what the people are asking for, and if the conduits were to be required to the forks of the roads the company would not undertake to put it in this fall.

Colonel Henry Lee said that the deprivation of rapid transit for one winter would be only a hardship, but the erection of wires would be an injustice that ought not to be allowed.

President Whitney, of the West End company, said that the greatest demand yet made upon the company has been that of rapid transit. It was with the view of meeting that demand that the company reluctantly turned toward the cable system, and were proceeding in good faith to construct such a system when attention was turned toward the electric system. It is not alone the people of Brighton and Brookline that are interested in this question, but every passenger on the road, for it is proposed to try the electric system on a scale that will admit of no question as to its feasibility. The company hopes by the experiments of the coming winter to demonstrate the working of its system, so that in the spring it can be extended all over the city. He thought the gentlemen who now oppose the road will, when once it is in operation, deem it an advantage to property instead of a drawback.

Alderman Wilson asked as to the danger to life from the wire, and in reply Mr. F. J. Sprague, vice-president of the Sprague company, explained that experience in Richmond has shown that no harm is to be feared from accidental contact, many of his men and even he himself having received the full strength of the current without injury. He would be willing to guarantee no breakage from storms. There will be no danger to passengers from the wires in the car, the protection being perfect; nor would there be danger in an electric storm, the car being protected by "lightning arresters" of tried worth.

The hearing was then closed, and on motion of alderman C. W. Smith, the matter was referred to the board as a committee of the whole, with instructions to give a public hearing.

Several gentlemen who believe that the overhead wires which the West End Street Railway Co. desires to erect in connection with its proposed electric motor system will disfigure certain beautiful sections of this city, have placed a remonstrance in the several club houses of the city, and at the offices of Jackson & Curtis, No. 24 Congress street; Lee, Higginson & Co., No. 50 State street; Kidder, Peabody & Co., No. 113 Devonshire street, and other places, for signatures; over 100 signatures have already been secured.

The aldermen, as a committee of the whole, gave a hearing on the 17th inst. on the petition of the West End Street Railway Co.

Mr. Frank Morison, the first remonstrant, read the remonstrance signed by himself and two hundred others, against the granting of the rights asked for, upon the ground that the overhead system would disfigure the avenue and endanger the public safety. Mr. L. S. Dabney owned a house on Beacon street, near Fairfield, not on the line of the road. He frequently had gone over the route proposed and was familiar with it. The avenue, which had been improved at great expense for pleasure driving, it was now proposed to encumber with wires, and cars moving without visible means of locomotion, to the detriment of the safety of those who drove horses.

Two other remonstrants were heard, followed by Mr. H. D. Hyde, representing the petitioners. Mr. Hyde disclaimed any philanthropic intentions, as alleged by the remonstrants, but had no doubt that Mr. Whitney would be commemorated as a benefactor to Boston. He believed that the mass of people should not be deprived of better transportation facilities by the opposition of the few, whose sentiment led them to oppose the overhead system. The opposition was based entirely upon a lack of understanding of what they consider a mysterious, ungovernable power. The remonstrants were evidently not aware of the wonderful development made in the last few years in the application of electric motors, and of the many advantages that leave no question as to their superiority over all other kinds of power for nearly all purposes. He called attention to the fact that the motion of an electric car can be instantly reversed. On this understanding the contracts were made with the Bentley-Knight, Sprague, and Thomson-Houston companies.

The West End Street Railway Co. would agree to put in an underground conduit as far as the city built sewers, and would give bond so to do, to the city or to abutters.

He believed the electric system was necessary and practicable.

Cambridge is to have the first installment of the West End electric street lines on the overhead system, the contract having been signed by president Whitney with the Thomson-Houston company to equip the road between Harvard square and Arlington over North avenue, a distance of 3⅛ miles. It is expected that it will be in full operation in sixty days, and continued to Bowdoin square upon its completion. This company is now equipping electric roads in Washington, Ottawa, Syracuse, Des Moines, and other places, and has about thirty roads in successful operation in different parts of the country. The West End Railway Co. own more than eight thousand horses and many thousands of cars, and the slowness of proceeding to supplant horse power with electricity is partly due to the large investment which it involves. On September 25 the Board of Alderman, by a unanimous vote, granted the West End Street Railway Company the right to use electricity as a motive power in operating its cars.

Boston is very well supplied with police signal boxes, the Municipal Signal Co. is the successful competitor. Their boxes are placed against the walls of buildings, and do not in any way obstruct the streets or sidewalks, and are successful in working.

BOSTON, September 26, 1888.

CHICAGO.

A Novel Move to Reduce Telephone Rates; Killing Two Birds with One Stone.—The Telephone Company and the City Councils.—Rapid Transit before Council.—Professor Barrett on Electric Motors, and on Underground Wires.—Fire in an Electric Light Station.—A Long-Distance Telephone Company Incorporated in Illinois.—The Lowth-Stetho Telephone Co.—Dr. Cushman still Hopeful.—The Great Western Telegraph Co.'s Suits.—The Fire Underwriters' Association of the Northwest.—Mr. G. A. Mayo engaged as Electrician by the Van Depoele Company.—Electric Lighting in the Grand Opera House.—Other Electric Light Notes. New Companies.—A New Cable laid by the Telephone Company. Echoes of the Recent Electrical Convention.

A PETITION was circulated on South Water street, recently asking the city council to reduce the telephone rates to $75 per annum. The young man who presented the paper claimed to be a representative of a firm of lawyers. He asked each merchant who signed the petition to add his name to an agreement to pay $5 or $10 should the object of the petition be obtained. Signers to both papers were said to have been numerous. It has been asserted that some of the aldermen are behind the scheme, and that they hope to share in the profits of the firm whose agent was circulating the petition. Alderman McGregor, who is chairman of the council committe on gas and electrical lights, said: "There will be action on this subject without this petition. Before we adjourned for the vacation it was intimated to me by a member of our committee that the telephone company was willing to make a reduction in rates if we would give it permission to string wires and put in new instruments. The rents are now too high. There is nothing to be hoped for from competition. I think $75 would be a good rental."

This prophecy was fulfilled. At the meeting of the city council September 10th, alderman Landon introduced an ordinance granting to the Chicago Telephone Co. the right to extend its system, the wires to be laid underground except in the outlying districts. It was referred to the committee on licenses. The company is now operating without a license owing to the disagreements which have arisen between the council and the company. The proposed ordinance contained no limitation of rentals to be charged. In

presenting it alderman Landon said he introduced it because he thought the company should have legal authority in operating in the city. No consideration, he said, was offered the city for the privilege beyond an agreement to furnish city officers with telephones without charge. He said he favored amendments limiting rentals and providing for license fees. This is the attitude of one of the more moderate aldermen. One of the more sensible councilmen, aldermen Ernst, introduced an order directing the law department to take immediate action to secure the vacating of the injunction which prevented interference with the telephone company's wires. He also introduced an ordinance limiting charges to $75 per year for telephone rental. Both measures were referred.

An ordinance granting a franchise to the West Chicago Rapid Transit Co., which proposes to employ "steam power, electricity, or other species of power," was referred.

The license committee next took hold of the telephone question. The corporation counsel was directed to prepare such an ordinance for the regulation of the telephone service as would fix the annual rental at $75 and would protect the city's interests. The corporation council declined to express an opinion as to the right of the council to adjust the rates.

The committee on streets and alleys took up the question of rapid transit at the meeting of September 17. J. M. Hannahs represented the system which bears his name. He said the company had obtained the right of way on West Lake street and Milwaukee avenue. The ordinance asked for provided for a system sufficient for an electric or steam system. The right of way had not been verified, and no action was taken.

Professor J. P. Barrett, city electrician, is a thorough believer in the future of the electric motor in Chicago. He said recently :— "It is taking a firm hold in the city, and when electrical privileges are granted it will be generally adopted." The professor believes in the underground system as constructed in Chicago. When he was in Minneapolis, recently, he gave this advice in an interview with a reporter of a daily paper :—

"Take away all those unsightly poles along which your wires are now stretched and it will improve your streets to an extent that you can hardly realize before the thing is done. And then there is the great danger of the electric light wires and the serious inconvenience to the firemen when called to take care of great fires. The cost of putting wires underground is no greater than stringing them on poles ; it only costs more at the start in putting in the underground system. There is no inconvenience from induction in the underground system. There is really better insulation. From the fact that the different classes of wires run through ducts and chambers the separation is practically greater. When the wires are once put through they are there for a long time. They are easier taken care of. Electrical or any other storms do not affect them, and that is the great gain. I have wires in Chicago that have not been seen in seven years and they give as good service as ever. There is no liability of getting wires crossed and the distribution is made much easier. And even counting the first cost of the underground system as greater than the other, I really believe that in five years the underground would be the more economical. In short, the advantages of the system are too numerous to mention. But, of course, it is to be expected that the capital invested in other systems will fight this one at first, though it will be to the advantage of all in the end. In Chicago, we have 5,000 miles of wire underground. We burn 1,100 arc lights there, but have not an inch of electric wire above ground. We have 13 miles of the Dorsett system, and it does good service. We have electric light and telegraph wires in the same conduits, and the reports are that the service is exactly as good as if they were farther separated. We are making the change to the new system gradually. In two years we have taken out 1,300 poles. In the suburban districts there is not so much need of immediate action. The underground system will surely come in use all over the country. In New York, I see the electric light people are making a fight, but they cannot hold out long. Public protection, public convenience and public policy demand the change."

Fire was discovered in the north side station of the Chicago Arc Light and Power Co., about 1 A. M., September 10th. Four dynamos and three Ball engines were badly damaged. The loss is estimated at $6,000. The cause of the fire is unknown. The engineer and firemen left the station about 15 minutes before the discovery of the fire and locked the doors. About 155 lights were run from the station. Two of the circuits carrying 92 of the lights were cut into the main station, and there was no interruption of the service. The balance of the lights were out for three or four days.

The American Telephone and Telegraph Co. was recently incorporated in Illinois for the purpose of constructing long-distance telephone lines. The following gentlemen are interested in the company : Norman Williams, George L. Phillips, and R. C. Whitmore. Work has been commenced on the line to Milwaukee. The greatest care will be taken in the construction. Forty foot poles will be employed. The line is to be operated in connection with the Chicago exchange of the Chicago Telephone Co. and the Milwaukee exchange of the Wisconsin Telephone Co. The charge for communication has not yet been decided upon. Long-distance telephone service has not been successful heretofore from Chicago. The reason given for the failure is that the wires which connected the city with Kenosha, Racine, Milwaukee, and other places, were strung on poles which contained a large number of telegraph wires. The latter interfered seriously with verbal communication.

The Lowth-Stetho Telephone Co., with a capital of $5,000,000, has been incorporated by James Lowth, Edwin S. Brown, Jr., and Allen C. Knapp. The instrument which the company proposes to introduce is the invention of James Lowth, of Chicago. Its action depends on muscular action or vibration, and makes no use of the air waves. For this reason it is alleged it does not infringe on the Bell instrument. The diaphragm is dispensed with and in its use the instrument is held to the ear with the transmitting part resting upon the muscles of the neck. The company is not ready at present to give any further explanation of the operation of the instrument. The object of the company is to engage in a general telephone business. It is claimed that with the Lowth instrument conversation can be carried on over a distance equal to any over which communication is practicable with the Bell instrument.

Dr. Cushman, who claims to be the original inventor of the telephone, says he is not at all discouraged by the recent decision against his company and in favor of the Bell company. He is confident that Judge Blodgett's decision can be reversed on appeal as he asserts it contains many errors. His confidence and optimism never desert him.

Mention has been made heretofore of suits instituted by Elias R. Bowen, receiver of the defunct Great Western Telegraph Co., against stockholders to compel them to pay up their stock in order that claims of creditors may be settled. In one instance the receiver was successful. Recently 33 persons who are the unfortunate owners of this unpaid stock commenced a suit in which they ask that a decree of the court which compels them to pay on their stock be set aside. About 2,800 stockholders are interested in the outcome of this action.

The nineteenth annual meeting of the Fire Underwriters' Association of the northwest, was held in Chicago, September 12 and 13. The only mention of electric lighting was in a paper on "Rates and Rating," by Charles E. Bliven, of Philadelphia. He referred to the phenomenal growth of this mode of illumination, and said it formed a new risk which the members would do well to investigate.

The Van Depoele Electric Manufacturing Co. has secured the services of George A. Mayo formerly of Elmira, N. Y., as electrician. He has been engaged on the new incandescent system which the company will soon put on the market. Mr. Van Depoele continues with the company as consulting electrician.

Electric lighting has been introduced in the Grand Opera House. There are 850 incandescent lamps employed. Current is furnished from the Edison central station. There are 90 lamps for foot lights, 30 each of red, white and blue globes. The arrangement is such that either set can be used according to the requirements of the scene.

The Jackson and Wells street bridges have been completed, and electric lights illuminate them.

The new reading room of the Chicago public library has been opened. It is lighted by 120 incandescent lights.

Electric light wires caused a blaze in the lathwork in the ceiling of the Union depot in Chicago, August 29. The fire was extinguished apparently but broke out again after the departure of the firemen. The loss was about $350.

The Clinton Electric Light, Heat and Power Co., of Clinton, Ill., has been formed with a capital stock of $25,000, by Vespasian Warner, Clifton H. Moore, John Warner, Abner R. Phares, and Richard Buller.

Adolph Graeff, Alfred Graeff and E. Graeff, have organized the Chicago Electric Light Enlarging Co., with $5,000 capital stock.

The Royal Electric Co., of Peoria, Ill., has been incorporated, with $10,000 capital stock. The incorporators are Charles W. Robinson, James W. Smith and Gustav A. Shaefer.

Articles of incorporation have been issued to the People's Light & Power Co., of Chicago. The capital stock is $100,000 and the incorporators are Charles P. Dose, John F. Buhmann and Charles C. Fricke.

The Electric Machinery Co , of Chicago, has been incorporated. The capital is $100,000, and the incorporators are E. H. Haynes, Charles Steinbreiss and H. B. Cody.

The Merchants' Arc Light & Power Co., of Chicago, has been incorporated. The capital stock is $200,000, and the incorporators are, Martin Kingman, E. C. Heidrich, Charles A. Jamison and G. H. Schimpff.

The Nutting Electric Manufacturing Co., of Chicago, has been organized by Samuel E. Nutting, W. H. Foulke and J. W. Hefenburg.

The Chicago Telephone Co. has been laying a cable across the Calumet river to provide East South Chicago with telephone service.

The western members of the Electric Light and Telephone Associations report that they had a royal time in New York city while attending the conventions. Of the warm hearted hospitality of the New Yorkers they cannot say enough in praise. The western members of the Electric Light Association are particu-

larly well satisfied with the selection of Chicago as the place of meeting for the annual session. Chicago is a city peculiarly adapted for conventions, so at least the residents assert. Its citizens are hospitable, they know how to entertain, and they can always furnish accommodations for all who come. Of these characteristics the city is proud to a marked degree, and doubtless its reputation will be sustained when the convention meets.

CHICAGO, September 18, 1888.

LITERATURE.

REVIEWS.

Introduction a la Physique Expérimentale: Par MM. A. TERQUEM et B. C. DAMIEN. Unités, calcul des erreurs, mesure des quantités primitives, longueurs, masse, temps. Paris: A. Hermann, librairie scientifique, 1888.

THIS treatise contains 284 pages, besides a preface and an obituary notice of Alfred Terquem by Mascart. The preface states that material was largely drawn from foreign sources, preparing the reader for numerous references to familiar English and German authorities, and briefly illustrates the scope of experimental physics by the case of falling bodies and that of the changes of volume and pressure exhibited by gases.

The object of the treatise is instruction in fundamental operations, not to lay out a series of laboratory exercises. The introduction treats, in two chapters, of units and of errors. The chapter on units is in effect an abridgement of "Everett's Units and Physical Constants." Nearly half of it is devoted to electricity and magnetism, which subjects are introduced by a very neat statement of the reason for beginning with magnetic, and passing thence through electro-magnetic, to electrostatic measurements. The chapter on errors is mostly an application of the method of least squares. A simpler method, credited to Mascart, is given for determining the co-efficients of linear equations. In all the equations of a set, one of the unknown quantities, as x, has its co-efficient reduced to unity by division, the sum is then made, and from it each of the reduced equations is subtracted, thus eliminating x. The same process is applied to the remaining equations until y is eliminated. After the introduction comes the first part in three chapters, devoted respectively to lengths, masses, time. Ordinary instruments, such as verniers, the dividing engine, and apparatus depending on reflected light are detailed fully and satisfactorily; suggestions being made here and there. For instance, the decimal vernier for circles is advocated as a step toward adoption of a decimal graduation of the circle, and a table for converting decimal readings to usual measures is promised as an appendix. Instructions for mechanical processes are limited to adjustments of apparatus.

The only recipes are one for Elliott Brothers' gum-lac cement, and one for silvering glass. The cement is made by dissolving 40 to 60 grains of gum-lac in 100 c. c. alcohol. The materials are put into a flask, a cork inserted and tied fast, and then all is subjected to treatment in a water bath until solution is secured. The cement is solid when cold, but softens when heated. The process for silvering, which is given in minute detail, is credited to Dr. Martin, of Foucault's laboratory, but is quite unlike the Foucault process given by Witz in his "Cours de Manipulations." The book is well adapted for use in conjunction with manuals like Stewart and Gee's Practical Physics, for example.

RECENT PUBLICATIONS.

Directory of Electric Arc Lighting Plants in North America. Cleveland, O. *The National Carbon Co.* Paper, 8vo., 92 pp.

Dynamo-Electric Machinery: A Manual for Students of Electrotechnics. By Silvanus P. Thompson, D. Sc.; B. A. Third Edition, enlarged and revised. London and New York: *E. & F. N. Spon*, 1888. Cloth, 8vo., 672 pp. Illustrated. Price $5.00.

Materialen fur Kostenvoranschlage electrischer Lichtungen. Von Etienne de Fodor, mit 69 Abbeldungen. *Wien, Pest, Leipzig.* A. Hartleben's Verlag, 1888. Paper, small 4to., 224 pp. Illustrated.

The Principles of Electric Lighting, including electric generation, measurement, storage and distribution. By Philip Atkinson, A. M., Ph. D. New York, 1888, D. Van Nostrand. Cloth, crown 8vo., 255 pages, illustr.

Treatise on Patent Estate, Comprehending Nature, Conditions and Limitations of Interest in Letters Patent. By Thos. B. Hall, of the Cleveland Bar, Cleveland, O. *Ingham, Clarke & Co.*, 1888. 12mo., sheep, 240 pp. Price, $2.00.

CATALOGUES AND PAMPHLETS RECEIVED.

Mr. R. Eickemeyer's remarkable dynamo (an illustrated description of which appeared in the ELECTRICAL ENGINEER for March last) is the subject of a pamphlet issued by J. H. Bunnell & Co., of New York—selling agents for the machine. In addition to a list of the sizes offered and their capacity, with a price list, the pamphlet gives a detailed and well illustrated description of the dynamo, and concludes with a reprint of Mr. Eickemeyer's paper read before the Electric Club, New York, March 3, 1887, entitled "Some Remarks on the Magnetic Circuit in its Relation to a New Type of Dynamo-Electric Machine."

The O'Keenan Electric Manufacturing Co., 45 Broadway, New York, issues an eight page circular setting forth its primary battery for electric lighting. This company, to its great credit, is more modest in its claims than the swarm of primary battery men that has infested electrical circles recently. It offers no new and startling battery, with unheard of E. M. F. at little or no cost, but simply a new form of sulphate of copper battery, in combination with accumulators and regulating devices, for use in isolated plants of small size, where motive power cannot be obtained conveniently. The plan seems to be of sufficient interest to invite the attention of people concerned with small isolated lighting plants.

The "Pocket Handbook of Copper and Iron Wire in Electric Transmission," issued by the Washburn & Moen Manufacturing Co., Worcester, Mass., in convenient vest-pocket form, is a very interesting and useful little compilation of electrical information. The Washburn & Moen company have taken the trouble to get together in small compass a considerable mass of electrical notes and memoranda from widely scattered sources, arranging and classifying them very conveniently for reference. An "Index of Current Electrical Literature" is included, consisting of a list of many electrical and engineering publications in the English language.

POINTERS.

.... IT'S better not to know so many things than to know so many things that are not so.—*Josh Billings.*

.... IN America there are 6,000 electro-motors working machinery; in Great Britain hardly 100.—*Professor Ayrton.*

.... WE seem now to be rapidly approaching the time when optics will be recognized as a mere branch of electro-magnetism. —*Electrician* (London).

.... IF we read the history of the past, I think we can scarcely fail to observe that Nature has revealed herself in a greater degree to those who have worshipped her in her simplicity.—*S. Alfred Varley.*

.... As a matter of fact, in 99 cases out of 100, the telegraphist delivers to the editor of a newspaper "copy" far more accurate than the first proof of his own leader submitted by the printer.—*W. H. Preece.*

.... IT has been found from actual practice in electric light work in identical central stations, that 20 per cent. more work is required in the case where countershafting is introduced.—*Professor George Forbes.*

.... AN incredible amount of power is daily running to waste in this and other countries because many of the rapid streams of water are too far away from towns for their power to have been hitherto utilized.—*Professor Ayrton.*

.... IT has been proved, from the experience of numerous central stations, that during a considerable number of hours in the night the load on the engines and dynamos is only one-eighth part of the maximum load.—*Professor George Forbes.*

.... THE work of the engineer is not of the earth earthy, is not mechanical to the exclusion of science, is not unintellectual; but it is of a most beneficent nature, is consistent with true poetical feeling, and is worthy of the highest order of intellect.—*Sir Frederick Bramwell.*

.... LOOK at the furnaces and boilers of a great steam engine driving a group of dynamos, and estimate the energy expended; and then look at the incandescent filaments of the lamps excited by them, and estimate how much of their radiated energy is of real service to the eye. It will be as the energy of a pitch pipe to an entire orchestra.—*Dr. Oliver Lodge.*

... I SAY that the introduction of prime-movers as a mere substitute for unintelligent manual labor is in itself a great aid to civilization and to the raising of humanity, by rendering it very difficult, if not impossible, for a human being to obtain a livelihood by unintelligent work,—the work of the horse in the mill, or of the turnspit.—*Sir Frederick Bramwell.*

.... HENCEFORTH I hope no learner will fail to be impressed with the theory-hypothesis—no longer—that electro-magnetic actions are due to a medium pervading all-known space, and that it is the same medium as the one by which light is propagated and that non-conductors can, and probably always do, as Professor Poynting has taught us, transmit electro-magnetic energy.—*G. F. Fitzgerald.*

.... THE American plan of basing a conclusion on experience rather than on anticipations, is not a bad one, and if we follow that plan, then taking into account that there are 75,000 arc lights alight every night on the Thomson-Houston high potential circuits throughout the world, and the comparatively small number of people that have suffered in consequence, we are compelled to conclude that high potential now is what 30 miles an hour was half a century ago—uncanny rather than dangerous.—*Professor Ayrton.*

.... THE agitators who want legislative interference against the use of high tension dynamos, should be consistent, and if the protection of human life is their real motive, they should attempt also to obtain legislation against the manufacture and use of high tension dynamite, nitro-glycerine, and other similar explosives; also against the use of gasoline lamps, burners and stoves, all of which produce their quota of victims almost daily. Further, against horse and foot races, rowing and swimming matches, base and foot-ball games, athletic sports, etc.—*Dr. P. H. Van der Weyde.*

NEWS AND NOTES.

THE NATIONAL TELEPHONE EXCHANGE ASSOCIATION.

TENTH ANNUAL MEETING, HOTEL BRUNSWICK, NEW YORK, SEPT. 4 AND 5, 1888.

The association assembled at 11 A. M., on Sept. 4th, the President, Mr. Henry Metzger, of Pittsburgh, in the chair.

President Metzger introduced Mr. Henry C. Davis, president of the Electric Club, of New York, who extended on behalf of the Electric Club and of the citizens of New York a cordial welcome in the following words:—

Mr. Davis—*Mr. President and Gentlemen of the National Telephone Exchange Association:* On behalf of the Electric Club of New York I am here to confirm our invitation of a year ago and extend to you a cordial welcome to our club, and I trust that you will enjoy yourselves there to the extent that your predecessors of last week, I believe, have done. In extending our invitation to you, the intention was that you should hold your convention in our lecture room, but I am happy to congratulate you upon your number being too large to be comfortably accommodated in our limited quarters. I also want to congratulate you upon the fact that you have only one parent company to deal with instead of a conglomeration of parent companies, as the National Electric Light Association has, each believing that their own apparatus is the best and the one that you ought to adopt and use. You have to a certain extent a kindred interest with that association, and I trust that your struggle with the underground conduit system will be a success.

President Metzger, on behalf of the association, returned thanks to President Davis for the invitation.

The secretary, Mr. C. H. Barney, then read his report showing that there were upon the roll 86 active, 5 associate and 29 honorary members. The routine work of his office had been much the same as the previous year. The publication of the *News Letter* had been continued, and it had been his privilege not only to visit the more important exchanges in New York and vicinity, but many others at distant points including Boston, Providence, Philadelphia, Pittsburgh, Cincinnati, Chicago, Minneapolis and St. Paul. The receipts of the year were $1,937.69, and the expenses, $1,953.17, thus drawing slightly upon the surplus of the previous year. The report was accepted and filed.

The treasurer, Mr. H. L. Storke made the following financial statement:—

DEBITS FOR YEAR.

Amount collected for dues	$1,900.00
Initiation fee	10.00
Extra sales of proceedings	27.69
Total	$1,937.69
Balance in hand	37.33
Total	$1,975.02

CREDITS FOR YEAR.

Secretary's salary	$1,200.00
Rent for office	120.00
Printing Pittsburgh proceedings	221.25
Other printing	138.80
Office expenses, postage, etc	152.51
Stenographer—Pittsburgh	59.25
Other expenses	61.36
Total	$1,953.17
Balance on hand, Sept. 4th, 1888	$21.85

Mr. Henry Metzger was then unanimously re-elected president. In accepting the office Mr. Metzger said:—

ADDRESS BY THE PRESIDENT.

I can only thank you for this evidence of renewed confidence on your part in re-electing me to the office of president. It is usual on occasions of this kind for a retiring president—to offer remarks upon matters germane to the purpose for which we have assembled. Every city, town and village in our country, from the Atlantic to the Pacific, from the borders of Canada to the Gulf of Mexico, gives visible evidence of the work you have performed in developing the telephone business. But I do not intend to take you back and recall the history of the past. It is sufficient for me to ask you to go to that period of time, one year ago, when we were assembled in the city of Pittsburgh. It was a time pregnant with uncertainties and doubts as to what the status of the telephone companies would be for the coming year. It is true that every Circuit Court of the United States, wherever the American Bell Telephone Company had brought suit, had granted preliminary and final injunctions against infringers, whether defended by government aid or by private wealth and influence. Yet there still remained a doubt as to what the final outcome would be. The uncertainties of the law were too well known to all of us, and although our faith in the righteousness of our cause was firmly grounded, yet some unexpected resistance might develop that would weaken our faith in the wisdom, justice and honesty of men. After a long, bitter and expensive struggle the day of judgment came. It was delivered by that honest and eminent jurist, Morrison R. Waite, the late Chief-Justice of the Supreme Court, whose memory, I think, the telephonic fraternity should revere, and over whose grave we can all shed the tear of regret at his untimely death. But before yielding up his life he placed the seal of judicial authority on the scroll of fame that bore the name of Alexander Graham Bell as the inventor of the speaking telephone. (Applause.) And in this connection I cannot forbear saying to the association that we are much indebted to those two eminent attorneys, J. J. Storrow and E. N. Dickerson, for their masterly knowledge of the science of telephony, and their keen analysis of the evidence as produced in the various causes which they argued. Since that time we have had a period of repose; a feeling of security has prevaded the minds of our stockholders in regard to the safety and permanency of their investments. In many other cases the directors of companies have entered into a more liberal policy, one more in accord with the necessity and requirements of the business. In some cases, notably in New York, Chicago, Baltimore and Pittsburgh, new buildings have been erected suitable for carrying on the business in which we are engaged. In some other cases underground systems have been laid—either a new plant or extensions of existing ones. Multiple switch-boards have taken the place of old systems that were a constant source of discomfort to subscribers and telephone managers. In some other cases larger poles have been erected, copper wire has largely taken the place of iron and steel, and good insulation the place of poor or perhaps none at all. But while much has been done, much more remains to be done in the next three or four years, if the members of this association desire to retain control of the business. In the sphere in which we move and perform our work we may be kings, but there is a greater circle beyond that in which a constant power is being exerted that will in a very short and limited time compel you—compel us all—to give the best of service and at a cheaper cost; so cheap, in fact, that your competitor of the future may well hesitate at the threshold before entering the field with hopes of successful venture. But the day of the inevitable conflict is coming, and it is your bounden duty to your stockholders and in justice to yourselves to prepare for that day. The maxims, "In days of peace prepare for war," or "Make hay while the sun shines," are worthy of your serious consideration. It will not do for you to fold your hands and rest content with the fruits of the legal victories of the American Bell Telephone Company. The competitor of the future will be no less relentless than the infringer of the past; watching every movement that you make, noting every step of progress, he is but waiting for the day and the opportunity either to divide the business with you or perhaps to absorb it entirely. I now, gentlemen, desire to return again my thanks for your very kind treatment of the chairman—from the time I first entered your service at Niagara Falls to the present moment. (Applause.)

The following additional officers were then elected: vice-president, W. D. Sargent; treasurer, H. L. Storke (re-elected); to the advisory committee, M. F. Tyler (re-elected); to the executive committee, S. M. Bryan, W. J. Denver, G. M. Stone and C. F. Cutler.

Invitations were then read from the American Telephone and Telegraph Company, for a drive in Central Park; from the Western Electric Company, to a dinner after the drive, at the Mount St. Vincent Hotel; from the Metropolitan Telephone Company to an excursion up the Hudson and dinner, including the spectacle "Nero" at Staten Island. These, together with the invitation of the Electric Club, were accepted.

Mr. F. A. Pickernell then read a paper on "Notes on Telephone Batteries." (See page 482.)

Mr. Gifford—Mr. Pickernell mentioned the fact that he used three Leclanché cells usually with the long-distance transmitter. I started out, rather on my own hook, to see how many cells were wanted. I commenced with 1, 2 and 3, and carried it up to 4, and found that 4 gave the best result. While I do not wish to have the association espouse the interest of any particular battery, I would like to know what battery has been found to be the best for long-distance transmitters. As a matter of fact we want to get at the very best battery—what has been found to be the best.

Mr. Seely—The Metropolitan Telephone Company, of New York, are putting in a storage battery for their transmitters, especially for the exchange work. We are about to use a cell we call "Type D," giving 7 amperes of current, an internal resistance to about $\frac{5}{1000}$ ohm, and 2 volts. Those batteries are about 7 inches high by 12 inches square.

Mr. Lockwood—I notice one point in Mr. Pickernell's paper which, since it differs from my own experiments, I think it proper to refer to especially. If I recollect aright he stated that we were to be careful in the use of Leclanché batteries not to use too much sal-ammoniac. If by using too much he means that we are not to fill the jars full and then try to moisten it, I agree with him. If, on the other hand, he means that we must be very chary about putting sal-ammoniac in, I cannot agree with him. I have found in the course of some 13 or 14 years of experience

in telephony and otherwise, that the amount which the dealers (especially the Leclanché Battery Company, who are very careful to send out nothing but good material) send out is exactly the amount which it is proper to use, and that we can neither diminish that nor increase it with advantage. It is true that crystals will form upon the zincs and upon the lower part of the carbon, but as long as crystals of sal-ammoniac only fall on the zinc no great harm will come. It is also a fact that when there is little sal-ammoniac in the solution, oxychlorides of zinc and ammonium at once form on the zinc, and these salts, being insoluble, take away just so much of the conducting surface of the zinc, and thus increase the resistance of the battery, besides preventing the necessary consumption of the zinc, which is absolutely essential to the proper working of a battery. I dare say when Mr. Pickernell comes to restate his views they will be found to be not far from those which I have enunciated. I am also very glad to note from what Mr. Seely says that the Metropolitan company is making an experiment in the way of using secondary cells. I should like to request Mr. Seely to make a careful observation of the working of such batteries, so that at our next meeting we may be enabled to know something about it.

Mr. Pickernell—I would state that I quite agree with Mr. Lockwood in respect to his statement about the use of sal-ammoniac. I mention that fact because I found that it was not infrequent for telephone inspectors to put in two of those packages of sal-ammoniac instead of one, thinking that by so doing they might possibly save a trip there in a short time. It is only about two weeks ago that I found 3 cells of battery which we were using on a long-distance transmitter in which the zincs were entirely covered with crystals of sal-ammoniac. My attention was called to that state of things because the transmitter would not work at all.

In reply to the question about the number of cells to be used with long-distance transmitters, we find, if we use low resistance batteries, that 3 cells are as good as 4, there being practically no difference. But if you have batteries in which the resistance is increased from any cause whatever you will find that 4 batteries are better than 3.

Mr. Gifford—One word in regard to sal-ammoniac. A short, practical rule that I have adopted is to allow an inspector to put in no more sal-ammoniac than you can dissolve in water. I do not leave any at the bottom of the cell at all. I found as Mr. Lockwood says he found, that some will load up a cell with 2 or 3 charges, so that they will not have to go back. I only allow them now to put in as much as you can dissolve. That varies according to the kind of water in different towns. In a town where you use lime water it will not hold so much sal-ammoniac in suspension as pure river or rain water will.

Mr. Thornberry—In my experience I rather favor the disposition of the batteries described by the gentleman who last spoke, in placing just enough sal-ammoniac in the battery to keep it doing its work. I want to say, in reference to the long-distance telephone, that where hard work is being done the Leclanché battery will hardly answer the purpose, if it is in an exchange where it is used frequently; but a 4 or 6-cell gravity battery will serve the purpose. That is to be determined by the length of the line in which you wish to work it or the condition of the battery itself. The sulphate of copper battery, or gravity battery, has to be constantly at work or it will polarize itself. If it is constantly at work and cleaned once a week, the gravity battery will give splendid results and give you splendid transmission for your long-distance telephone.

Mr. Bailey—The point aimed at seems to be to get an effective working battery of low internal resistance. Has any one experimented with the Leclanché batteries on any kind of telephone in multiple? In using them in multiple you would get much lower internal resistance, I should say, and. of course, a greater quantity of current.

Mr. Lockwood—Some two or three years ago the chief clerk of our company, Mr. R. W. Devonshire, sent me two or three transmitters with the instruction—I don't know whether it was directed to me specially, or whether it was in the nature of a circular—which gave me the exact information how much battery I ought to use for the long-distance transmitter. I did not follow the instructions with great care, and I tried them with a number of cells of different kinds. I tried them with 1, 2, 3 and 4 cells of Fuller and different bichromate combinations. I tried them with 1, 2, 3, 4, 5 and 6 cells of Leclanché and other similar batteries, and I tried them, as Mr. Bailey has spoken of, 3 in tandem and 2 abreast, 3 in series and 2 in multiple arc, and I found that while that arrangement was new it worked beautifully. It furnished the proper amount of current, or at least it furnished a very good amount of current, and it worked very nicely. But when that battery grew a little older, I found that it did not work as well, because it was impossible to make the two sides work alike; one side got a little stronger and kept getting a little stronger than the other. Consequently, instead of both parts of the current going one way, the stronger battery took a notion to polarize or go against the current of the other side. A better way would be to do, what I am surprised battery manufacturing companies have not done before, *i. e.* to make a larger Leclanché cell. Possibly they have done it before, but it has not got into the market. A demand has come, however, for a Leclanché cell about twice the size of the present cell. I think that we shall have to put our trust still in the peroxide of manganese battery until we can find that peroxide of lead is as constant as peroxide of manganese, and it is a proper thing, I think, for manufacturers to consider whether they had not better increase the size of them.

Mr. Seely—The present plan of the Metropolitan company is to make an inspection once every month. The solution is thrown out and a new solution made up. Each inspector is provided with a measure holding four ounces of sal-ammoniac. We guard against overcharging the batteries in that manner. We find that the Gonda porous cup is about as good as the Leclanché battery. Taking the current at the electrodes of the battery we find that we get 1.7 volts with an internal resistance of 1.7 ohms. After using that battery through a resistance of 8 ohms for five minutes we find that the voltage falls to 1.3 volts, the current to .5 ampere and the internal resistance has increased to 2.6 ohms. Short circuiting of the battery for an hour and five minutes we get .3 volt and .3 ampere and 1 ohm internal resistance. That battery was far ahead of any we experimented with.

The convention then adjourned till 2:30 P. M., and remained in executive session until 5 P. M.

SECOND DAY, WEDNESDAY, SEPT. 5.

The meeting was called to order by President Metzger at 10 A. M., and Mr. C. L. McCluer read a paper on "Dynamo Current Interferences with Telephone Systems, and Means of Relief." (See page 483.)

Mr. Lockwood—I would like to ask Mr. McCluer whether he has made a point of having his return conductor parallel with his main lines.

Mr. McCluer—Of course, in every instance. I have only, so far, in the Richmond exchange provided one common return wire; that is, up Ninth and Broad streets, and up Broad street to the western extremity, with branches radiating along the lateral wires. Of course this wire is carried on the same pole and parallel to all the wires connected to it.

Mr. Lockwood—Mr. McCluer is quite right, I think, in attributing a certain amount, at least, of the disturbances, and perhaps, nearly all the disturbance, occurring from the electric railway to absolute leakage of the electricity from the rails to the telephone wires; but like nearly every person who has at one time adopted one theory for certain phenomena, and at another time another theory, I think he has become an extremist, and, as is usual, the mean is the correct view. A great deal of our disturbance on telephone lines is still due to the old enemy—induction, and although the telephone business is eleven years old now, induction is still just as strong as it ever was. The trouble that electric lighting, and especially arc lighting, has given to telephone men are of two-fold character; first, of the character which disturbs the conversation; and secondly, of the character which destroys the wires and apparatus. Within the last year or two we have become apprised of another enemy in the lighting camp, namely, the alternating current used for incandescent lighting, and these are used not only through converters, but also on direct circuits. The telephone line which runs from the Malden central office, in Boston, to my own house is a very much disturbed line indeed, and I allow it to remain there, so that I can study the phenomena. But we formerly had a Thomson-Houston direct arc lighting machine, with a three-plate commutator, and the noise was bad then; but lately they have taken to lighting Melrose, where I live, with incandescent lamps placed in a direct circuit and operated with an alternating machine, and the noise is now tremendous, because the alternations are almost as quick as the telephone alternations, namely about 200 per second.

A paper was then read by Mr. T. D. Lockwood on "The Electrical Relations of Telephone and Electric Light and Power Circuits and Railways." (See page 485.)

Mr. Lockwood (after reading his paper)—Now one word as to Mr. McCluer's device. It is true that the evil he has had to encounter is actual leakage from the rails, and that it has manifested itself both by affecting the apparatus and by affecting the conversation, and there was no reason even before he tried his device to doubt that it would do its work. I do not know whether it has totally eliminated the noise, but if it softened it down fifty per cent., as he says, if it has made it bearable so that people can talk, a great deal has been done. Since the beginning of the telephone business, I think some six hundred patents have been issued for different forms of telephone, and I think perhaps from three to four thousand patents for telephone appliances, out of which perhaps two hundred have directly or indirectly referred to apparatus for reducing, eliminating or neutralizing induction. A great many are not worth the paper they are written on. But this device of a return circuit I think probably was first indicated by the old way in which those of us who were telegraph men used to run what we called combination locals. We used to have a number or combination of local battery cells, one for each sounder, and we would bring them all

back over a common wire. A little later, when the telephone business began, quite a number of people, myself among others, patented a system in which a common return wire was provided for a group of circuits. That was in 1880. In the application for a patent that I put in, we had a narrow escape from an interference with some of Mr. Scribner's applications for patents on devices which afterwards went into use throughout Indiana, Ohio and Illinois as the Wiley-Scribner Telephone Exchange system. Since then, the very idea of using a common return as an induction neutralizer has been patented by a man named Bentley, and within the last six months the American Bell Telephone Company bought that patent with a lot of others (the American Bell Telephone Company buys patents so that its licensees can use them). I have not made these observations with the idea of belittling Mr. McCluer's invention, because there is not the slightest doubt that he invented it independently and for his own work, but simply to say that none of the rest of you, if you wish to use it, need hesitate for fear of trenching on his prerogatives, because it is open to every one of you who are licensees of the Bell telephone company.

Mr. Durant—We have for three years used that device and have it in use now. I think it is applied on twenty-four wires. It came into use from the interference of the Heisler incandescent system, which uses an alternating current. Presuming, of course, that the Heisler circuits were constructed in conformity with the rules of the Board of Public Improvements, namely, in close parallel lines, we did not examine them, and we put this common return wire in use, and we found it very effective. In the meantime we found that Mr. Heisler had one side of his circuit on the side of this street where our wires were, and the other on the other side. We made him correct that.

Mr. Bailey—There is another point I want to call your attention to—that matter of danger of dead wires in relation to lightning trouble. We have had a little of it out in our country. Of course, we have a system that covers a good deal of country, and is made up largely of country lines, and in the changes in telephone business dead wires occur with us, as they do with every one else, and dead wires are sometimes a good deal more costly than living ones. The usual course of proceeding when a telephone is discontinued is to take the telephone out without making any provision for the wires which are left standing. The question is, - During a thunderstorm, what will become of a current that may gather on that wire without any connection to the earth? It certainly has to discharge somewhere, and in discharging, it is likely to do a good deal of damage. It strikes me that it is similar to the case of a defective lightning rod—a lightning rod which has no earth connection. We have a case of that kind where a loop was taken out on one of our lines. The line got charged from a thunderstorm, and the lightning followed in on those open wires and struck a child and knocked it insensible. It recovered without any apparent damage, but it was a thing that, it strikes me, should be guarded against. Wires of that kind should be removed from the premises.

Mr. Farnham—Mr. McCluer suggested an idea, which I think, may be misunderstood and might be misleading. He said that in a large place where there were several electric light wires running one might offset, in a certain sense, the induction from another wire, and so the difficulty need not be as serious as it would be where there was only one circuit. I have found in several cases, in looking up these same troubles, that the electric light people have taken that ground and have said that their system was all right, because, notwithstanding the fact that each circuit was a belt circuit, yet the several belt circuits were on the same pole with what they call the positive pole of the machine, and that consequently the interference of one line would be neutralized by the interference of an entirely separate circuit. Of course, we will find, if we try it, that this is altogether false, because we cannot have two machines running at precisely the same speed and the changes of current coming together at precisely the same moment of time, and while there may be, in listening at a telephone, a moment when the noise is less, the next moment it will be very severe. One of the noisiest exchanges that we have is where the circuits run in belts on the same poles, and yet there is no balance whatever. I speak of that because unless we understand it thoroughly and are ready to answer the electric light people's question in that matter, we may get ourselves into trouble. The only way to remedy that is to take two of those circuits and make a metallic circuit, if there happen to be four or six circuits, taking the same general route, of course, that can be arranged so that there will be a metallic circuit of each individual circuit on the same poles without materially increasing the obstruction. In speaking of the electric railways, nothing was said, I think, in the paper or in the remarks about the feed wire. Sprague's system uses a feed wire. I do not know about the Richmond system, but I do know one system in New England where this feed wire is also a bare wire. It certainly is bad enough to use a bare trolley wire with a grounded circuit, but where the excuse is for using a bare wire in places where our wires are liable to touch them at any time I cannot conceive.

Dr. P. H. Van der Weyde—I am in a position to mention certain results in regard to a general return wire which I obtained in a series of experiments that I made some years ago, with the purpose of economizing the wires with a double metallic circuit, and having one general return wire. I found that if a general return wire, substituted for a ground wire, is not close to the direct wire, it is of no use. I found that it is only reliable when the wires are all near together as in a cable. Therefore, I adopted the system of making as far as possible a well insulated return wire of low resistance in the centre.

Mr. Seely—I would like to state our experience with a common return wire for subscribers. In New York city, in 1885, we put up a Patterson cable. In those days they made a cable with a large centre core. I think it was a No. 6 wire. We connected to that cable some five hundred subscribers. We grounded that central core in the central office. While that cable worked fairly well and cut down the induction and cross-talk and leakage, we discovered by ringing up a subscriber on a long wire, that we would also ring up a subscriber on a short wire, and that with two wires of the same comparative resistance, if two subscribers would attempt to talk at the same time, the cross-talk between those two relative wires would be very severe. We immediately abandoned the scheme and considered it useless. I would also like to state, while I am here before the convention, that I presume in New York city we have a larger number of electric light wires in the air than are in any other city in the world. All systems are represented here. It is the policy of the Metropolitan company to grant pole privileges to those companies. We have a blank form on which they make application to the company, and by so granting them permission to erect their wires on the property of the Metropolitan company we are in a position to dictate to them; we tell them exactly how we desire their wires to be constructed; how many lamps on each circuit, whether we should divide the lamps in positive and negative sets. The East River Electric Light Company have about 2,200 or 2,500 attachments on our poles, and their wires are built in the most excellent manner. We are suffering very little from the leakage from their currents. They use the Thomson-Houston system, and are giving us no trouble whatever.

Mr. Thornberry—Providing this return wire is almost as expensive as it would be to the electric light company if they returned their wire, which in equity and justice they should do, it seems to me that the telephone companies should not establish a precedent which the electric light companies may force them to follow afterward. It is only right that they should put their systems in such a condition as not to interfere with your service. If you are on the ground first you have vested rights. I think the convention ought to take some action in coöperation with the National Electric Light Association. I was almost ready to make a proposal that this association appoint a committee who might meet a committee from the National Electric Light Association to discuss the matter of providing methods and means whereby we might harmonize the interests of the two associations.

Mr. Lockwood—We cannot deal with an association in these matters. We have got to deal with separate companies and individuals. An association—even this association—has no authority from any one of its members, though we are bound together by common interests and common ties, much less can another one with several major conflicting interests, and several hundred minor conflicting interests, behind its members. It would be at this time a thoroughly useless and futile thing to do.

Mr. McCluer—If the members of the association will allow me, I would like to occupy a few moments of their time in making a little plainer one or two points that have been brought up since the discussion began. In the first place, with reference to the metallic circuit and the common return wire; as a matter of course, I have known for years that the metallic circuits and common return wires have been in use. I did not suppose that I was originating anything new in devising a simple metallic circuit or a simple return wire. But I do believe that I did devise something new when I devised what I call a compound metallic circuit—a metallic circuit with one wire only to serve the purpose of a return wire with an unlimited number of wires attached to it. I also believe that I have devised a new idea in substituting a metallic conductor in place of the earth without any earth conduction at all. I am perfectly familiar with Mr. Bentley's and Mr. Marbury's patents. They are both for anti-induction cables, and to apply these systems to telephone exchange plants would necessitate the entire reconstruction of the plants. The system that I propose to use does not require anything of the kind—not a solitary wire on poles or house-top fixtures has to be changed or altered in any way; all that has to be done is to put up one additional wire for every wire—I do not care what the number is, one or two, or a dozen, or hundreds of wires on the same route, and the only change that has to be made in the system is the simple substitution of this common return wire for the ground. To prove that, I will state that I have in the Richmond telephone exchange to-day eighty-seven stations connected on to a single return conductor. That conductor starts from the central office with a number 4 covered copper wire extended to a distance of half a mile from the central office. Connected to that is half

a mile of No. 6 covered copper wire, and continuing the wire runs a mile from the office; beyond that it is my intention to use a No. 8 copper wire to reach the various stations of the subscribers. I have now one such wire only in use in Richmond, extending from my central office up Ninth street to Broad, and thence out from Broad to the terminus. On that wire I have eighty-seven stations connected just exactly as they were before, to the earth, and by means of a plug switch which I have in the central office I can use that common return wire either as a general ground wire, making all these subscribers' wires take earth at the central office, or, by removing this plug, I can disconnect them entirely from earth and use them as metallic circuits. Of course I could not conceive it possible that no one had tried this arrangement before; it was so simple in itself. It was only after making the experiment I did, that I induced our officers to allow me to make this practical test. When I made my first practical test and connected my first ten or twenty stations on the first half mile of copper wire, I was exceedingly interested in how the result would be. The very next night after it was done, I went to the central office. I spent nearly two hours, from ten to twelve o'clock, with four or five of my inspectors, going to different stations that we could get into on this line, and all of them talking over the different circuits at the same time, all of them ringing over different circuits, and doing it all simultaneously; there was no interference. I have repeatedly gone to my office at night, taken this plug out of the switch and disconnected the systems from the ground entirely, got two, three, four and six people to talk at the same time on different wires on that circuit, and not one could hear a word that the other said—not as much cross-talk on that as on wires I have running down Carey street on the same pole. Now that is a fact. Of course, as I stated, I made inquiries from some of my electrical friends that I thought might possibly have heard of the adoption of this principle before I did, but it was new to them, as it was to me, and I never had seen any intimation of anything of the kind being done, in any of the public prints, although I am a subscriber to two or three technical journals. I then disclosed the plan to our executive officers, and had a good deal of correspondence with them with reference to the matter before any decision was arrived at. During the progress of our correspondence I heard that Mr. Durant, of St. Louis, had tried the return ground system, and as it was told me, without any result. I was also told that an English electrician, a telephone man, had reported that in England they had tried the same thing and had found they obtained a better result by connecting the two ends of this common return wire to the ground also, using the earth and the wire together. Well, that was a revelation to me. I thought possibly there might be something in it. I had not thought of trying it before, but I did try it, and just the very moment that the earth was connected on the wire again, the same interference that we had before showed itself, but the very moment the earth was disconnected from the common return wire, all this interference disappeared. I am only giving you facts, and facts that I have verified in every way that I can. Mr. Lockwood says he did not understand me to say that it was my intention or expectation to connect any considerable number of wires to the same line. I do propose to do that. I propose to have only one wire of large conductivity on every line of poles. It does not matter whether the pole carries twenty-five wires or two hundred and fifty wires.

Dr. Van der Weyde—I wish only to state that according to my experiments it is possible for twenty or thirty operators on a telephone line to communicate with one single return wire. My experiments were made five years ago in anticipation of the necessity of putting the wires underground. Then I got, by the kindness of the telephone company, the use of a number of cables containing some hundred wires and a central wire. They call it the Patterson cable. But the results were unfavorable, for the reason that this cable was connected at both ends with the ground.

Mr. Reilly—I would like to say that something over three years ago we had occasion to run a common return ground, such as Mr. McCluer described, to overcome the induction from the Delany synchronous multiplex telegraph on a line parallel with ours for about five miles. We ran a No. 12 copper wire for about four miles, and connected it to six stations, and almost entirely overcame the noises from the telegraph wire, and suffered no interference whatever from ringing from one station to another, and had no interference from cross-talk. That line is still in use and giving satisfaction.

Mr. Seely—Mr. Lockwood referred in his paper to the great disadvantage and the great amount of trouble caused by dead wires hanging in the way. I would like to say that I think every city should have a subway commission. Of course we have one, though it is very much abused. But they are removing the dead wires fast in New York city; they take down the poles and wires, and the companies have no trouble whatever in removing the dead wire. They do it for them.

The secretary then read a paper by Mr. W. D. Sargent, on "Underground Work in Brooklyn, N. Y." (See page 488.)

Mr. L. F. Beckwith followed with his paper on "The New York Subways." (See page 487.)

Mr. E. F. Sherwood then read a paper on "The Telephone Exchanges for the City of New York." (See page 489.)

Mr. Durant—I want to speak of the system we have in use between St. Louis and East St. Louis. The exchange at East St. Louis consists of only 50 subscribers, and about 90 per cent. of the traffic of that exchange is with St. Louis. Ordinarily in the Law system the trunk line business is done over two receiving wires, one from exchange A and exchange B, and the other from exchange B and exchange A, and we have that same arrangement between St. Louis and East St. Louis. However, the ordinary method is for the receiving operator to throw a telephone and transmitter into the sending call wire and give an order, expressed by numbers to the receiving operator. In the case of East St. Louis, which is occupied by an open circuit call wire which runs to the operator at the central office at East St. Louis, that line is extended—it is not grounded at East St. Louis—but it is extended to the receiving operator at East St. Louis. Consequently the order for office at East St. Louis is heard by both operators—by the one at East St. Louis and also by the one at St. Louis. The direction of the traffic is indicated by numbers. The numbering series at St. Louis commences at 100 and runs up to 5,000, while the numbering at East St. Louis is confined to the 5,000 series. When the subscriber at East St. Louis gives his order, of course the direction of the connection is expressed in the way given. That order is overheard by the operator at St. Louis and without any word between them they select the lowest number idle trunk line, and the connection is made without any word passing between them. If any of you can beat that on the trunk line service we would like to know it.

Mr. Seely—I would like to state, Mr. Chairman, that we are using a call wire precisely as Mr. Durant describes, with the exception of the St. Louis circuit. The operator, who could formerly handle only 7 trunk wires, is at the present time handling 50 trunk wires. Instead of sending and receiving trunk wires she virtually becomes a switchman at No. 1 exchange, while the operators at No. 2 exchange are simply calling into her from the call wire. I presume the company is saving $10,000 or $12,000 a year in salaries on the trunk line system alone.

The secretary then read a paper by Dr. S. M. Plush on "The Telephone." (See page 490.)

Mr. Durant—I do not believe there is a class of men in the world who appreciate the telephone less than the men engaged in the business. The reading of Dr. Plush's paper called to mind a statement made to me by the manager of one of the largest and best papers in the country, published at St. Louis. He told me that on the night of the earthquake—it occurred about 12 or 1 o'clock at night—that inside of two hours he called up 103 stations in various parts of the city, and got two columns of very interesting matter showing the effect of the shock in various parts of the city. That will perhaps show its value in one direction. The capacity of an operator under great stress was decided in our exchange, I think, last January, under the direction of Mr. Doolittle, and if any of you have not made that test I would suggest to you to make it, to show the number of connections that can be made in a given time by a single operator. On this test 53 were made in five minutes.

By a vote of the association, Minneapolis was selected as the place of meeting next year

A paper was then taken as read by Mr. McCully on "An Interesting Judicial Opinion as to the Rights of a Telephone Company against House Movers."

Mr. Kerr—The question of taxation by the boroughs, by the cities, by the townships and by the state, has caused the Pennsylvania Telephone Company a good deal of trouble. I believe the law in Pennsylvania is in a mixed up condition, and it is probable that members of the convention here could throw some light upon the subject which would assist us in determining what course we ought to pursue. The Pennsylvania law, I believe, as to the taxation authorized by boroughs is that boroughs can only tax after the analogy of the taxation by the county commissioners. The act signed by the governor of Pennsylvania on the 24th or the 25th of May, 1887, gave the cities of seven classes the right to tax telegraph, telephone, electric light and power companies; that is to charge a license tax. There are, however, decisions by the Pennsylvania courts which show perfectly distinctly that the plant of a corporation cannot be taxed. Notable among these is the Coatesville company's decision which is constantly cited by the Western Union and by other companies interested in the matter. It was there decided that plant was capital and could not be taxed. Now, almost every city and borough in which our company is interested is trained to tax and is trained to institute a pole tax. The Western Union Telegraph Company has recently secured a decision of the Supreme Court of the United States that a pole tax is illegal. I believe that is on the principle that the line is an interstate line and the business an inter-state business. However, there is another principle on which the Western Union Telegraph Company is now standing, that the boroughs and cities have a right to tax and to charge this license tax only on a police principle, and this license tax cannot be a tax per pole but must be a tax on the telegraph property in proportion to the value which the telegraph property bears to the other property taxed on the

police principle in the city. This has reduced the Baltimore & Ohio Telegraph Company's tax in one city, I am told by J. B. Stewart, superintendent of that company in Baltimore, to the sum of 39 cents, whereas the effort to tax was something like a $1 a pole. If any company represented in the convention can name any principle which governs other states or which is established by the law of other states, which would form a precedent, as Pennsylvania law is undecided, it would be very useful. If any person, also, has seen a decision of the Supreme Court of the United States which is to the effect that the tax must be a tax on the police principle and in proportion to the value that telephone or telegraph property bears to other city property it would be very useful, because the establishment of such a principle by the Supreme Court of the United States would render it impossible for any city or borough to tax at so much per pole, and as the cities and boroughs are trained to tax at so much per pole it would be a very important thing for telephone companies to know whether we could not on some legal basis established by the Supreme Court of the United States contest that effort of the boroughs.

The only other question I have to ask is that if there be any such principle established by the Supreme Court of the United States, whether there be within the knowledge of gentlemen present any principle established by the Supreme Courts of other states which could form a precedent towards establishing the law in Pennsylvania.

Mr. Gifford—The matter has never been brought before the courts of the state of Kentucky. I suppose there are always some persons in every legislature who from motives of patriotism or some other "ism" like to put a heavy tax on corporations. But we appeared before the committee on law and taxation in the Kentucky legislature and stated our case to them, and they decided to levy a state tax in this way: One-fourth of one per cent. upon our gross receipts in lieu of all other state taxes. While that is little more than the average rate that other people have to pay on their property we deemed it policy to consent to it, and it is the law. In the state of Kentucky machinery in operation is not taxed, and our assessors have considered that our central office system, our bells, telephone and transmitters come under the head of machinery, and they are not taxed. I have been in the habit of going to the assessor and asking him what he thought the thing was worth provided the patent was removed. I would say, "What would you give for those wires and poles around here?" He would say so many thousand dollars, and he taxed it that way, and we paid as we would on any other personal property at that rate. We also have a very reasonable business license. We are perfectly satisfied with it. It is about two and a half times what the average license is. The city license in the City of Louisville is based upon one dollar upon a thousand. At that rate our tax would be $125 or $150. They have assessed a license tax of $250 a year. We thought it would not pay to quarrel with the municipal authorities for $125, and we acquiesced in that. We anticipate no trouble from the tax question there; but nothing of the kind has ever been brought before the courts.

Mr. Durant—I presume that every possible question that could arise under the various laws authorizing taxation has been raised in the state of Missouri and passed upon, and as a rule all those things go to the Supreme Court. We pay a tax upon our personal property the same as any other city in the state. In addition to that the City of St. Louis is authorized by its charter to impose a license tax upon sundry callings, and it was a question whether they had that right to impose it on a telephone company. We concluded that it was very much better than a tax upon our poles, and when the matter was under consideration we concluded we preferred that. The result was that we pay an annual tax upon our gross receipts; it amounts to a considerable sum, and after 1890 it doubles.

Mr. Bailey—Do I understand the gentleman to say that he pays a tax on his gross receipts to the city government as well as the state?

Mr. Durant—No; we pay the tax on our gross receipts to the state. We pay the tax on our personal property—it would be to the county, but as a matter of fact the City of St. Louis is an independent locality by itself; it is not in any county. There is a county of St. Louis and a City of St. Louis, but they are independent organizations. The City of St. Louis used to be in the county of St. Louis, but by its special charter adopted some 12 years ago, it is independent of the county. We pay the tax on personal property to the collector of taxes. We pay the tax on the gross receipts within the confines of St. Louis city to the city treasury.

Mr. Drake—There are very simple matters in vogue in Iowa and Nebraska of taxation. In Nebraska the companies report their property direct to the state auditor. The statements are laid before the board of equalization. They assess the property and then assign to each county its proportion. The county authorities then collect the municipal and state taxes. In Iowa the state board of equalization fixes the assessments upon statements from the companies and levies the tax direct. The tax is paid to the state treasurer, and that is in lieu of all other taxes of every description. No other city or county authorities have any right to levy any tax on any telephone or telegraph property.

Mr. Durant—Are you quite sure that any city in Nebraska has a right to license?

Mr. Drake—In Nebraska they have a right to levy an occupation tax; that is a special prerogative bestowed upon municipalities; it is a tax upon the business, not upon the property.

Mr. Durant—Are those occupations specified in the charter of the City of Omaha?

Mr. Drake—Yes, sir.

Mr. Durant—And the telephone and telegraph companies are omitted from the list?

Mr. Drake—No; they are included in Nebraska. You, as an individual, may own a good piece of property on which you pay a special state and county tax. On that piece of property you are conducting a business. They will issue you a license to do a business in the town.

Mr. Durant—Why cannot they license you to do a telephone business in the City of Omaha?

Mr. Drake—They do not in the City of Omaha, but they do in many of the towns and cities.

Mr. Durant—Then, that license tax is in addition to the personal property tax?

Mr. Drake—Yes.

Mr. Mailey—I would like our president to give us some light on the tax question as to the states of Pennsylvania and Ohio.

Mr. Metzger—It seems to me that the tax question is a political one, and I cannot see how or in what way this association can affect the method or mode of taxation. In Pennsylvania, of course, we are taxed upon our gross receipts, and also upon the dividends. I think the tax is eight-tenths of one per cent. on our gross receipts, and then three mills upon every one per cent. of our dividends based upon our capital stock. In the smaller towns of Pennsylvania we are not taxed for poles. In the City of Pittsburgh proper we are taxed for business purposes. That is all the tax that we pay for business purposes, and, of course, we are taxed at the same rate as all other classes of business based upon the amount of sales or receipts. But there is no tax on poles, or wires, or telephones. In the state of Ohio they tax us on the poles. There they have a property tax. The tax is on the value of the plant, and they have sought, of late years, to tax us on the telephones. We have resisted this so far successfully, and we are taxed precisely the same as all other citizens are taxed. We think that we are entitled to pay our taxes just the same as the citizen who owns a house and lot, or in fact any other corporation.

In the state of Ohio we have no state tax. Of course, we exist there by comity between the states under the rule that a corporation chartered in one state may transact business in another state. We have another town in the western part of the state, called Newcastle. A member of the council there did not pay his bill, and we brought him up with a round turn and compelled him to pay his bill. In the tax ordinance he moved that the telephone companies pay $250 as a license tax. The electric light companies were taxed $125; the natural gas companies were taxed $125, and so on, depending upon the character of the business. We told the council plainly that we would resist the payment of that tax; that they had no right to discriminate; that if they taxed us the same as they taxed all other companies on the same volume of business, that we would pay; that we are not going to pay $250, when the natural gas companies whose revenues were 10 times greater than ours, paid only $125. What the result of that case will be, I don't know, but I am inclined to believe that the council will modify the action in that regard and tax us the same as they taxed the other companies. At least, if they do not, we shall resist it by all legal means that we have at our command.

The Chairman—I take it that Mr. Kerr wanted to get information as to the valuation of the telephone property as a basis for taxation as much as anything else. It might be interesting to get views of members from various parts of the country on that. In my experience I have had struggles with various assessors over their extravagant ideas of the values of poles and wires.

Mr. Gifford—If that is the subject, I would say that we make our returns based on the original cost of the plant, and from that we deduct 10 per cent. annually for depreciation. We make that return under oath, because we believe that is a fair statement of the actual value of the plant.

Mr. Bailey—I would inquire if in making those returns the president includes his corporation appliances or merely what we might term personal property and buildings. There was a law in Pennsylvania that a corporation was free from local taxation, and was only subject to the general taxation law of the state. In Pennsylvania, I think, the great bulk of the entire state government was carried on by taxation of corporations. Railroad and other corporations, gas companies and water companies, have fought that all the way through, and uniformly with success. About a year ago there was, as Mr. Kerr says, a law passed allowing cities to tax telephones and telephone companies at a certain rate. We have never made any resistance to what they attempted to do. The generality of cities have levied what they call a police tax—a police franchise, and rather than bring up the question, we have paid it cheerfully. Some of the smaller towns have

attempted the same thing. So far I have been able to throw them off the track by going and seeing the council—generally the council's attorneys, and arguing the question with them with the uniform results of having them withdraw all the claims. There is one case that I have in mind that, by agreement between our attorneys, was settled by a case stated; that is a question of law to be heard before a judge of the Court of Common Pleas; that has not come up yet.

Mr. Metzger—I would say, in regard to Mr. Bailey's remark, that there was an act passed in 1887, authorizing the creation of cities of the fourth, fifth, sixth and seventh class. That act gave express authority to councils to levy a tax on telephone companies in the language of the act. It is under the act that these councils are acting. They do not fix any rate, however; they leave it optional with the city council as to what it shall be.

The secretary's statistics were ordered printed, instead of being read, and the convention adjourned.

COURT OF PATENT APPEALS.

REPORT OF COMMITTEE ON THE JUDICIARY—HOUSE OF REPRESENTATIVES.

On September 12, the bill before Congress to create a Court of Patent Appeals, came up on a report submitted by Mr. Culbertson, of the judiciary committee. The report is as follows:—

[To accompany bill H. R. 9,084.]

The committee on the Judiciary, to whom was referred the bill (H. R. 9,084) to establish a court of patent appeals, have considered the same, and report it to the House and recommend its passage with amendments herewith submitted.

The court of patent appeals as provided for by the bill and amendments reported by the committee, consists of one chief justice and two associate justices, who shall be appointed by the President, by and with the advice and consent of the Senate, and who shall hold office during good behavior, and receive a salary each of $6,000 per annum.

The associate justices shall take precedence according to the dates of their commission, or, when the date of the commissions may be the same, according to age.

The bill provides for the appointment of a clerk, deputy clerks, marshal, and reporter by the court. The fees of the clerk shall be the same as now allowed by law to the clerk of the Supreme Court, but shall not exceed $6,000 a year. The salary of the marshal is fixed at $2,000 per annum.

The pay of the reporter is not to exceed $2,500 annually, unless the number of reports required to be printed shall be increased by order of the court, in which case the salary or pay may be increased not exceeding $1,500 a year.

The court is required to hold one term annually at the seat of government, commencing on the second Monday in October, and may hold special or adjourned terms as the court may deem proper for the despatch of business.

The jurisdiction of the court as prescribed and defined in the bill is as follows:—

SEC. 14. The court of patent appeals of the United States shall have appellate jurisdiction in the cases hereafter specially provided for without regard to the sum in controversy.

1st. "From the courts of the United States having original jurisdiction of cases touching patents, copyrights, trade-marks, and labels, in all cases involving these subjects."

2. From the Commissioner of Patents in all cases touching the patentability of inventions, priority of invention among several claimants for patent upon the same invention, and in all cases of re-issue and the judicial practice of the Patent Office, also all cases touching the registration of trade-marks or labels and the rights of conflicting claimants therefor.

SEC. 15. From and after the passage of this act there shall be no appeal from the circuit courts of the United States or any territorial or district court or court of the District of Columbia, in cases touching patents, trade-marks, copyrights, or labels to the Supreme Court of the United States directly, but all such cases formerly appealable to the Supreme Court shall be heard on appeal by the court of patent appeals.

SEC. 16. There shall be a right of appeal from the court of patent appeals to the Supreme Court of the United States in all cases regardless of the amount in controversy; subject to the same regulations, however, as now exist with regard to appeals to the Supreme Court in causes of admiralty and the maritime jurisdiction, and to such further regulations as the Supreme Court of the United States may make.

SEC. 17. All cases touching patents, trade-marks, copyrights, or labels now pending before the Supreme Court of the United States awaiting trial shall be transferred to and heard by the court of patent appeals.

The expediency and propriety of, if not necessity for the establisement of, such a court as contemplated by this measure will not be questioned if proper consideration be given to the objects that will be attained by the passage of this bill.

Among the results reasonably expected to flow from the organization of a court of patent appeals, attention may be called to the following:—

(1) It would enable the public and patentees to determine the value and validity of patents without serious and vexatious delays, and thus promote the interests of all concerned.

(2) It will relieve the Supreme Court of much of the burden imposed upon it by this class of litigation.

(3) The practice in the Patent Office would become thoroughly fixed and understood and, as a consequence, the issue of worthless patents, in which unscrupulous persons deal to the injury of the public, would be greatly diminished, if not entirely suppressed.

(4) It would tend to simplifying the patent laws by con striction and settling questions of doubt which are often used by litigants for the purpose of injustice and oppression.

Without intending to present the reasons at length which induce your committee to arrive at the foregoing conclusions the following observations are submitted:—

The life of a patent, at most, is seventeen years, and if it is a valuable one, or intricate and radical, it usually requires one-fourth of that period to introduce it and secure its use by the public.

This, in part, results from the fact that manufacturers who must be relied upon to make and introduce new inventions are slow and reluctant to place in general use inventions which displace or render valueless articles in the production of which they are already engaged.

This is illustrated by experts, who say that to change from one style of gun to another requires from $1,000 to $2,000, and from six months to a year's time to make the model gun from which to make the dies, gauges, special tools, etc., and that to make these latter much time and money are required.

When ordinarily the financial life of a patent is abridged by the difficulties of placing the invention into general use, we can appreciate the importance of speedy decisions when it is infringed or when its validity is questioned.

Under the present condition of the business of the courts it requires, ordinarily, from two to three years to obtain a decision in the Circuit Court of the United States, and if appealed to the Supreme Court from three to four years are required to obtain a decision. It may be said that the same difficulty and delay attend the determination of all other questions involving the determination of property rights. While this is true, it should be borne in mind that this species or character of property differs from all other kinds of property. The duration of the owner's title is arbitrarily fixed by law. The period is short, for the most part, seventeen years.

The Constitution imposes upon Congress the duty of securing to authors and inventors, for a limited time, the exclusive right to their respective writings and inventions. It is submitted, respectfully, that this duty is very imperfectly discharged when, by the omission of Congress to provide proper means to determine questions arising out of patents, the life of a patent may be frittered away by the delays of the law.

As has been said, it requires from three to four years after a cause is filed in the Supreme Court to obtain a decision. This does not result from any fault of the judges. It is due solely to the fact that Congress has so broadened the appellate jurisdiction of the court as to overburden the physical capacity of the tribunal.

The original jurisdiction of the court, fortunately, is fixed by the Constitution, and Congress can not add to it or subtract from it, but the appellate jurisdiction of the court is subject to the power of Congress, and that authority has been exercised without proper regard to the physical capacity of the judges or the interests of litigants.

This condition ought not to be continued. It operates in a great many cases as a denial of justice, and every citizen of the United States is interested in bringing about a change.

It may be asked how this measure will contribute to that result? To that inquiry it may be answered that by the sixteenth section of the bill as quoted herein, it is provided that appeals from the court proposed to be established to the Supreme Court shall be subject to the same regulations as now exist with regard to appeals to the Supreme Court in causes of admiralty and maritime jurisdiction, and to such further regulations as the Supreme Court may make.

By reference to the act of 1875, relating to the practice in the courts of the United States in cases of admiralty upon appeals to the Supreme Court and the rule of the Supreme Court upon that subject, it will be observed that the Circuit Court is required to make a finding of facts and law, and the review of the judgments of the circuit courts by the Supreme Court in these cases is confined to questions of law only.

It follows that if a similar rule shall be applied to patent cases as the sixteenth section of the act provides, the Supreme Court in reviewing the judgments of the court proposed to be established will pass upon questions of law only, and thus from 15 to 20 per cent. of the time now consumed by the court in these cases in wading through voluminous records endeavoring to find the facts will be saved and profitably applied to the disposition of other business in the court.

It is difficult to perceive any good reason for requiring the Supreme Court to find the facts in patent cases and not in admiralty cases.

Upon the score of economy it is respectfully submitted that the expenses of this court will not exceed $30,000 per annum.

Such a sum of money bears no comparison to the amount that will be saved to the people of the United States by the speedy adjudication of questions arising out of patents. To this should be added also the incalculable advantage that will result to litigants

in the Supreme Court of the United States from the saving of time.

The income of the Patent Office for the fiscal year ending June 30, 1888, was $1,122,994.88 ; expenses, $953,730.14 ; leaving a surplus turned into the Treasury of the United States of $169,264.74, which, added to the previously credited surplus, makes a balance in the treasury to the credit of the patent fund of $3,337,666.65.

SEPTEMBER 12, 1888.—Committed to the Committee of the Whole House on the state of the Union and ordered to be printed.

AN ELECTRIC LIGHTING STATION A NUISANCE.

Supreme Court—Chambers.—New York.

PHILIP BRAENDER AGAINST THE HARLEM LIGHTING CO.

O'Brien, *J.*—The defendant sought to be enjoined is maintaining an electric lighting station adjoining plaintiff's houses on East 122d street, and though various grievances are alleged in the complaint, upon the trial only one was insisted upon, viz.; that the engines and machinery of defendant placed in the rear of the main building and working at night, jar plaintiff's buildings and create noises which are unusual and ill-timed. The station was erected and the machinery in the main building was running when plaintiff purchased the property. Subsequent thereto an extension was built in which a 400 h. p. engine was placed, which turns a cog wheel 16 feet in diameter.

The extension is shown to have been constructed in a good and substantial manner, and though complaint is made that the engine is driven by a cog wheel instead of belting, there is no dispute but that the engine itself was of the very best make and was built upon piers of solid brick.

It being shown that the buildings and engines were constructed in the best manner, the business itself carried on as well and carefully as such a business can be, and the neighborhood being such as not to make the establishment of a lighting station improper, it cannot be claimed to be a nuisance *per se*. Not being, therefore, a public or general nuisance, plaintiff, to succeed, must show some special injury to himself.

The two grounds of special injury sought to be proved were :—

First—Physical injury to the houses.

Secondly—Unusual disturbance and annoyance to tenants from noise and vibration caused by the engine and machinery in the extension.

These grounds, supported by evidence and showing permanent injury and continuing damage, would entitle plaintiff to an injunction.

I am, of course, familiar with decisions holding that the injury, annoyance or interference with the enjoyment of property must be substantial and real, the law not regarding trifles. The rule is well stated in Doellner *v.* Tynan, 38 How. 176 : "That if defendant is conducting his business in a convenient and proper part of the city, and in a careful and orderly manner, and it should not be interfered with merely because such business is incidentally annoying to the plaintiff * * * * or even render the enjoyment of his property uncomfortable."

This principle thus laid down is to be considered in connection with the rule laid down in McKeon *v.* Lee, 51 N. Y., 100 ; reported below in 4 Robertson).

This was an action wherein an injunction was granted against noise and vibration from an engine in a stone cutting establishment wherein the court says : "It may also be assumed for the purpose of testing plaintiff's right to relief that the defendant's business was lawful and publicly beneficial and conducted with every reasonable precaution as to the character of his building and machinery and mode of using them. This presents the naked question, whether the lawful character of the results of an occupation, trade or mechanical art, or the care with which it is carried on, can prevent any right of action by those whose enjoyment of life and property is disturbed by the mode or means of conducting such occupation."

Applying this test to the facts in this case as to the first ground—viz.: physical injury to buildings—I do not regard the evidence as proving such injury to be of a very substantial or permanent character. The buildings themselves have not been substantially injured, and the most that can be claimed is, that for purposes of immediate sale the causes complained of might injuriously affect the price.

A removal of the cause would operate a removal of the injury.

Upon the second ground—viz., unusual disturbance and annoyance to tenants—I regard the plaintiff upon the evidence as having a substantial grievance.

While the witnesses variously characterized the character and effect of the noise and motion of the machinery, whether we assume it to be only such a noise and vibration as is caused by a fire engine or ice wagon running past the houses as testified to by some, or as such a jarring and disturbance as to compel tenants to remove from the houses as testified to by others, either can hardly be regarded as trifling or harmless.

Regarding only the lesser of the two, while the passage of a fire engine or ice wagon occasionally would not interfere with the enjoyment of a house, the constant and uninterrupted rushing past of a fire engine or ice wagon might become an intolerable nuisance.

One of the controlling considerations, however, to my mind is the fact that before this large engine was placed in the extension the company conducted its business in an unobjectionable way, and the evils complained of did not then exist.

It would seem that for lack of space or to economize or concentrate power the company used the large engine and ran the machinery by a 16 foot cog wheel instead of having smaller engines and a wheel with belting. The motion of this large engine and cog wheel concededly produced the damage. It would appear as though the injury might be avoided. The 150 h. p. engine does the city's lighting, which is one-third of the entire business, and defendant had and has three of these smaller engines working with belting and direct attachment causing no trouble. It would seemingly, therefore, be but a matter either of convenience, expense or space to obviate the cause of the injury.

I know defendant claims that the substitution of smaller machines or of belting for the cog wheel, would require much more ground than they at present possess at 122d street. To accommodate their growing business they are erecting a new and enlarged station, now nearly completed, which will contain all their machinery. Their present station will then be entirely removed.

The defendant testified to the expenditure of about $200,000 for machinery, etc. It is at present supplying under contract with the city all the electric lights for the streets in Harlem, besides merchants and trades-people in that district, and the effect of an immediate injunction might prove ruinous to defendant, besides subjecting many persons using the lights and the city to much inconvenience. I am not unmindful, moreover, of the fact that much of the injury complained of, if suffered to be continued for a short time longer, can be compensated for in damages.

Taking into consideration the additional fact that the injury to defendant by the issuance of an injunction which would compel an immediate suspension of business would be greater than the benefit accruing to plaintiff, I am of opinion that while plaintiff should have judgment, the defendant should be allowed some time, to be fixed by the decree, to remove its plant before the judgment take effect.

Judgment accordingly. Filed September 17, 1888.

INTERNATIONAL TRAMWAY CONGRESS.

No very tangible results have been obtained by the International Tramway Congress, which opened here on Thursday last. The first matters discussed related to provident institutions, pensions, horses' rations, and to various kinds of tramway wheels. M. Michelet, chairman of the Brussels Tramway Company, read a paper on "Electric Traction," in which he stated that the difficulties experienced at first had now been removed by the accumulator plates being made larger and lighter, and at the same time stronger. The tramway company had kept accurate accounts of the expenses in connection with their accumulators ; a special account was kept for each battery of accumulators which was credited 10 centimes per kilometer run, and the various accounts were carefully compared. Each car ran from 100 to 110 kilometers per day, while each of the accumulators was used over about 40 kilometers per day. The company had found electric traction quite as dear as horse traction ; but improvements were pending which would bring about a reduction in the expenses. With regard to the question of working tramway systems, the director of the Vienna Steam Tramway considered that a tramway train should be composed of seven or eight cars, each carrying at least forty passengers ; that the surface of the platform should be reduced, and that the tickets should be delivered at stations, and not during the journey. A visit was paid to the accumulator charging station of the Brussels Tramway Company, and an inspection was also made of the Rowan steam cars used on the Brussels Schepdael line. The next meeting of the congress will be held at Milan in September, 1889, and the following one at Copenhagen in 1890.—*Industries.*

SUBMARINE CABLES.—CABLE CONCESSION IN HAWAII.

The Minister of the Interior has been authorized to enter into a contract with J. Sherman Bartholomew, residing in Honolulu, Hawaiian Islands, or with any other persons or corporation, for the construction and maintaining of a submarine telegraph cable or cables to connect the islands of the Hawaiian group from Hawaii to Kauai, as follows : From Hawaii to Maui, from Maui to Oahu, with a landing on Molokai, and from Oahu to Kauai, together with lines of land telegraph to connect the same with all or any points on the Hawaiian Islands. The contractors will have exclusive rights for submarine cables and connecting land lines for 10 years. It is provided that the cables shall be ready for use by July 1, 1889. The sum appropriated as a subsidy for the cable lines is $25,000.

LONG-DISTANCE TELEPHONY IN GERMANY.

The telephone lines Berlin-Dresden and Berlin-Breslau are completed. The distances are 105 and 200 miles respectively. The Dresden line was opened for traffic just recently, and the line may be used by telephone subscribers from their own instruments, and also by the general public making use of the call offices throughout the town or at the Bourse. The charge is 1s. for five minutes' conversation. The Breslau line is yet the subject of experiments by the post office, but will also shortly be opened for traffic.

ELECTRIC LIGHT AND POWER.

THE ATLANTIC COTTON MILLS, of Lawrence, Mass., have increased their Waterhouse arc light plant 77 arc lights, making 122 arc lights of the Waterhouse system in use at their mill.

THE PEOPLE'S ELECTRIC Co., of Easthampton, Mass., have ordered a combined arc and incandescent plant of the Waterhouse Electric and Manufacturing Co., of Hartford, Conn.

THE BRUSH ELECTRIC LIGHT CO'S station at Rochester, N. Y., is located at the foot of the Lower Genesee Falls, over 200 feet below top of the river bluff. The falls are over 300 feet wide and 94 feet high and are distant two and a half miles from the centre of the city.

The station is built of stone, three stories in height, 45 feet wide and 95 feet long; the penstock and wheel room are cut out of the solid rock. The building is fire-proof having iron joists, rafters and roofing. The dynamos are placed in the third story, in rows, and belt direct to turbine shafting in second story. The building is reached from the bluff by means of a large hydraulic elevator, the elevator well also contains all the wires for 26 circuits, and there is room for as many more.

The turbines are placed in heavy iron casings fastened to heavy iron beams bolted to the solid rock. The shafting runs at a speed of 800 revolutions, all journal bearings are fastened to iron bridge-trees, water is delivered to these turbines through three iron penstocks, six feet in diameter, each turbine is supplied through an independent elbow. At present 12 double 15 inch Lesner turbines are in use, and casings are placed for three more.

The dynamos in use are 25 No. 8 and 2 No. 7 Brush. The service now includes 1,150 arcs, 800 incandescent and 296 motors; power is furnished to two elevators, three laundries, 10 printing offices, three bakeries, telephone exchange, 61 tailor shops, 10 tea and coffee stores, and various other trades. The officers of the company are, G. E. Mumford, president; C. B. Griffith, secretary; Geo. A. Redman, superintendent.

.... * * * IT is a curious and suggestive fact that all moral forces and all moral questions find their final solution in the facts and laws of physical nature.—*Abram S. Hewitt.*

.... THE perfected alternating current motor is destined to play a most important and remarkable part in the development and commercial introduction of electric railways.—*Elias E. Ries.*

.... One scarcely knows which fact is the more astounding,—the distance at which the human voice can be reproduced, or the ridiculously simple apparatus that performs the reproduction.—*W. H. Preece.*

.... ANYONE looking at a common glow-worm must be struck with the fact that not by ordinary combustion, nor yet on the steam engine and dynamo principle, is that easy light produced. Very little waste radiation is there from phosphorescent things in general.—*Dr. Oliver Lodge.*

.... WE laugh a good deal at the rough and ready manner adopted on the other side of the Atlantic. The Americans, no doubt, are very ignorant of the difficulties that properly minded people would meet with; but it is a blissful ignorance where it is folly to be wise.—*Professor Ayrton.*

.... EVERYONE knows that combustion is not a pleasant or healthy mode of obtaining light; but everybody does not realize that neither is incandescence a satisfactory and unwasteful method, which is likely to be practiced for more than a few decades, or perhaps a century.—*Dr. Oliver Lodge.*

.... MANY calculations recall very forcibly the account given by John Phœnix (Lieut. Derby) of his experience in making a survey for the government of the distance from San Diego to the Mission Dolores. The method adopted was triangulation; but not having a full set of the proper instruments he used a three-legged stool instead. The instrument indicated a distance slightly in excess of seven miles; but for the purpose of correcting possible errors due to the personal equation of the observer and possible defects in the instrument, Phœnix stepped into a grocery, and taking an observation at the barkeeper through a glass, asked him what the distance was: The answer was that it was "about three mile and a half." Averaging this reply with the measurements obtained after the methods prescribed by science, Phœnix found the "true mean distance" to be five miles, three furlongs, and two and a half yards, and so reported to the government.—*Detroit Free Press.*

THE TELEPHONE.

MESSRS. MOURLON & Co., of Brussels, have received an order from the Portuguese government for all the material necessary for the erection of a telephone and telegraph line between Oporto and Lisbon, similar to those at present existing between Paris and Brussels, and Lyons and Marseilles.

PERSONAL MENTION.

MR. FRANK E. CLARK has resigned the treasurership of the Campbell Electrical Supply Co., Boston.

MR. W. A. GILES has accepted a position with the Sawyer-Man Electric Co., and will represent them as agent in the State of New York.

MANUFACTURING AND TRADE NOTES.

THE Clark standard cell, as improved mechanically by Mr. Durand Woodman, of Newark, who until recently has been employed in the testing dapartment of the United States Electric Lighting Co., possesses the merit of being portable, and unlike the ordinary Clark cell its usefulness is not destroyed by upsetting or by an accidental jar. A test made this summer at the Edison laboratory of two independent Clark cells made by Mr. Woodman, showed that after six months' use they agreed with each other within 0.00012 volt, or about 0.009 per cent. at the same temperature.

THE NEW ENGLAND GLASS WORKS of W. L. Libbey & Son Co., established in Boston in the year 1818, recently removed to Toledo, Ohio, owing to the advantages offered by that city as a centre for natural gas for fuel. The arrival of several hundred employés was the occasion of addresses of welcome, a parade and a banquet, to which the *Toledo Blade* devoted several columns of interesting matter. The factory, constructed under the supervision of Mr. E. D. Libbey, president of the company, is built in the latest and most approved manner, almost fire-proof, and with an especial view to the comfort and convenience of the workmen.

The well-wishes of the citizens of Toledo are echoed by the electrical fraternity, by whom the New England Glass Works have been so long and favorably known.

JAMES J. HICKS, 8, 9 and 10 Hatton Garden, London, E. C., sends us an illustrated and descriptive price list of new patent electrical instruments by G. L. Addenbrooke, embracing reflecting galvanometers, improved lamps and scales, Wheatstone bridges; together with keys and appliances for metrical apparatus. Mr. Hicks is the sole manufacturer of Mr. Addenbrooke's instruments.

MOORE BROTHERS, 108 Liberty street, New York, have issued their catalogue and price list No. 24, embracing a general line of telegraphic and other electrical instruments and supplies.

THE W. F. & JOHN BARNES Co., Rockford Ill., have recently sent out a new catalogue showing all the changes, improvements and additions made of late in their foot, hand and steam power machinery. Both amateurs and manufacturers will find much of interest in the catalogue of the Messrs. Barnes—embracing machines for a great variety of uses.

THE engines of the Ball Engine Co., Erie, Pa., have attracted much attention on the part of electric lighting companies, and many of their engines are now employed in that service. The Ball Co. has just issued a tasteful pamphlet circular, descriptive and illustrative of the special features of its engines, and containing other matters of interest to electric light engineers.

IT is very rarely that the patents of any one person comprise all the features necessary for the control of a system of great commercial utility, and we are glad to note that the several patents of Butz, Thompson, Bradford and others have been combined in the system of automatic temperature regulation recently placed on the market by the Consolidated Temperature Controlling Co., of Minneapolis, Minn., whose plan possesses the merit of being relatively simple in construction and convenient in use.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

ABBREVIATIONS.—mi., miles of single track; g., gauge; lb., pounds rail per yard; m., electric motors; c., cars; m. c., motor-cars; h. p., horse-power; T., T-rail. Name of electric system used is in SMALL CAPITALS.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scaife; *Sec.*, Arthur Kennedy; *Tr.*, Jas. B. Scott; *Supt.*, Alexander Moffat; *Eng.*, ——; 3-7 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 200 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.* Jno. B. Wallace; *Sec.* and *Treas.* Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½; 45 lb.; 8 m. c.; 1 m.; sta. —— h. p.; overhead cond. THOMSON-HOUSTON.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Tr.*, F. W. Harriman; *G. M.*, A. A. Johnson; *Eng.*, N. M. Edwards; 3.5 mi.; g., 4-8½; 35 lbs.; 5 c.; 5 m. c.; sta., 60 h. p.; water power; overhead cond. VAN DEPOELE.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Sec.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Birmingham, Ct.—Derby Horse Railway Co.—*Pr.*, H. H. Wood; *Sec.*, Wm. J. Clark; *Treas.*, Chas. E. Clarke; 4 mi.; 94′ 8½″; m 5; c. 4; h. p. 100. VAN DEPOELE.

Brockton, Mass.—East Side St. Ry. Co.—*Pr.*, A. F. Small; *Clerk*, C. A. Noyes; *Tr.*, C. D. Fullerton; *Eng.*, E. L. Brown; 4½ mi.; g. 4-8½; 40 lb.; 4 m. c.; steam-power sta. 60 h. p.; overhead cond.; 4 m. c. SPRAGUE.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; *G. M.*, John Aldrich; 5 mi.; g. 4-8½; 30 and 60 lb.; 3 m. c.; 1 m.; steam power; sta. 75 h. p.; overhead cond. SPRAGUE.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper; *Sec.*, J. R. Murdock; *Tr.* and *G. M.*, G. B. Kerper; *Supt.*, R. Palley; *Eng.*, H. Kolf; 1 mi.; g. 5-2½; 52 lb.; 3 m. c.; 3 m. overhead cond.

Columbus, O.—Columbus Consolidated Street Ry. Co.—*Pr.*, A. D. Rodgers; 2 mi.; g. 5-2; 2 m. c.; 30 lbs.; 2 c.; sta., 250 h. p.; underground conduit. SHORT.

Davenport, Iowa.—Davenport Central St. Ry.—*Pr.*, W. M. Grant; *Sec.*, G. S. McNeil; *Tr.*, J. B. Fidlar; *Supt.*, J. W. Howard; 3½ mi.; 8 m. c.; overhead cond. SPRAGUE.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 3 m. c.; sta. 240 h. p.; overhead and conduit cond. THOMSON-HOUSTON.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 2 mi.; g.——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. VAN DEPOELE. Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit cond. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; *Supt.*, Mr. Richardson; 1 mi.; g. 5-2; 35 lb.; 2 m. c.; sta. 40 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1; 1 m.; sta. —— h. p.; conduit VAN DEPOELE.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—*Pr.*, W. J. Calder; *Sec.*, D. Fleming; *Tr.*, T. D. Greenawalt; *Supt.*, J. Schaffner; 4.5 mi.; g. 5.2½; 52 lbs.; sta. 160 h. p.; 10 m. c.; overhead cond. SPRAGUE.

Hartford, Conn—Hartford & Weathersfield Horse R. R. Co.—*Pr.*, E. S. Goodrich; *Sec.*, D. R. Howe; 12 mi.; g. 4-8½; 45 lb.; 2 m. c.; overhead cond. SPRAGUE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, D. W. Burdick; *Sec.*, J. Murray Mitchell; *Tr.* T. F. Van Fleet; 1 mi.; g. 4-8½; 30 lb. T.; 2 m. c.; sta. 20 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Lafayette, Ind.—Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2.25 mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 4 mi.; g. 4-8½; 40 lb.; T; 6 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Meriden, Conn.—New Horse R. R.—*Pr.*, T. J. Lathram; *Sec.* and *Tr.*, T. A. Lamb; 5 mi.; g. 4-8½; 35 lb.; 12 m. c.; overhead cond. DAFT.

Meriden, Conn.—Meriden Horse R.R. Co.—*Pr.*, Geo. R. Curtis; *Sec.* and *Tr.*, C. L. Rockwell; *Supt.*, D. Barker; 5 mi.; g. 4-8; 35 lb.; 12 m. c. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. THOMSON-HOUSTON.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair St. Ry.—*Pr.*, Theo. Evans; *Tr.*, Henry Stamm; *Sec.*, J. W. Patterson; 2½ mi.; g. 5-2½; 43 lb.; 5 c.; 5 m.; steam-power; sta. 200 h. p.; overhead and conduit cond. SPRAGUE.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt.*, Jas. H. Talbot; 2.75 mi.; g. 4-8½; 27 lb.; 3 m. c.; sta. 55 h. p.; overhead cond. THOMSON-HOUSTON.

Richmond, Va.—The Richmond Union Pass. Ry. Co.—*Pr.*, W. R. Trigg; *Sec.* and *Tr.*, Andred Pizzini; *G. M.*; G. A. Burt; *Eng.* A. L. Johnston; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 400 h. p.; overhead cond. SPRAGUE.

Salem, Mass.—Naumkeag St. Ry. Co.—*Pr.*, C. Odell; *Tr.*, H. Wheatland; *Sec.*, J. F. Hickey; *Supt.*, W. B. Furgurson; 1½ mi. Willows branch; g. 4-8½; 6 m. c.; 35 lb.; 80 p. c.; sta. 100 h. p.; 6 m. c.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Franceeco; 9 mi.; 4 m. c.; overhead cond. HENRY.

San Jose, Cal.—San Jose & Santa Clara R. R. Co.—*Pr.*, S. A. Bishop; *Sec.*, E. Rosenthall; *Tr.*, J. Rich; *Supt.*, W. Fitts; 10 mi.; g. 3; 6 m. c.; sta. 130 h. p; conduit cond. FISCHER.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. McMaugh; *Eng.*, W. S. Smith; 5.75 mi.; g. 4-8½; 30 lb.; 4c.; 12 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

St. Joseph, Mo.—St. Joseph Union Pass. Ry. Co.—*Pr.*, Seymour Jenkins; *Sec.* and *Tr.*, A. Steinacker; *Supt.*, Chas. Wilson; 9½ mi.; g. 4-8½; 35 lb.; 8 m. c.; 13 m. c.; overhead cond. SPRAGUE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Tr.*, T. F. Torrey; *Supt.* and *G. M.*, B. T. Killam; *Eng.*, J. Nazel; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 14 m. c.; sta. 300 h. p.; overhead cond. THOMSON-HOUSTON.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, W. B. Cogswell; *Sec.* and *Tr.*, W. S. Wales; 4 mi.; g. 4-8½; 35-50 lb.; 8 m. c.; overhead cond. THOMSON-HOUSTON.

Washington, D. C.—Eckington & Soldier's Home Ry. Co.—Overhead cond. THOMSON-HOUSTON.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 12 m. c.; sta. 240 h. p.; overhead cond. THOMSON-HOUSTON.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—*Pr.*, H. H. Sen; *Sec.*, W. E. Shupp; *Tr.*, C. Walter; *Supt.*, A. C. Robertson; 3-6 mi.; g. 5-2; 50 lb.; 7 m. c.; sta. 120 h. p.; overhead cond. SPRAGUE.

Wilmington, Del.—Wilmington City Ry. Co.—*Pr.*, W. Canby; *Sec.* and *Tr.* J. F. Miller; *Supt.*, W. H. Burnett; 6½ mi.; g. 5-2; 47 lb.; 13 m. c.; overhead cond. SPRAGUE.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.5 mi.; g. 3-6; 25 lb.; 1 c.; 1 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb T; 1 m. c.; sta. 1,000 h. p.; overhead cond. THOMSON-HOUSTON.

Constructing or Under Contract.

Akron, Ohio.—Akron Electric Ry. Co. 6½ mi.; 12 m. c.; overhead cond SPRAGUE.

Asheville, N. C.—Asheville St. Ry.—3 miles; 4 m. c.; overhead cond. SPRAGUE.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—*Pr.*, H. G. Bacon; *Tr.*, J. E. Draper; *G. M.*, H. M. Daggert, Jr.; 6 mi.; g. —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond.

Bangor, Me.—

Boston, Mass.—West End Ry. Co., Brookline branch.—12 mi.; 20 m. c.; overhead cond. SPRAGUE.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown; *G. M.*, E. Scott; 4 mi.; g. 4-8½; 25 lb.

Cleveland, O.—East Cleveland R. R. Co.—*Pr.*, A. Everett; *Sec.* and *Tr.*, H. A. Everett; *Supt.*, E. Duty; 23½ mi.; g. 4-8½; 45 lb.; 16 m. c.; overhead cond. SPRAGUE.

Danville, Va.—Danville St. C. Co.—*Pr.*, T. B. Fitzgerald; *Sec.* and *Tr.*, P. R. Jones; *Supt.*, M. W. Buckley; 1.6 mi.; g. 4-8½; 38 lb.; overhead cond. THOMSON-HOUSTON.

Des Moines, Iowa.—Capital City St. Ry. Co.—*Pr.*, G. Van Ginkel; *Sec.*, H. E. Teachout; *Tr.*, J. Weber; 7 mi.; g. 4-8½; 45 lb.; 8 m. c.; overhead cond THOMSON-HOUSTON.

Elsinore, Cal.—Elsinore Lake Shore Elect. Ry. Co.—*Pr.*, D. G. Dexter; *Sec* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.

Erie, Pa.—Erie City Pass. R. R. Co.—*Pr.*, W. W. Reed; *Sec.*, J. L. Sternberg; *Supt.*, Jacob Borst.; 8½ mi.; g. 4-8½; 20 m. c.; overhead cond. SPRAGUE.

Flushing, N. Y.—Flushing & College Point St. R. R.—*Pr.*, J. Dykes; *Sec.*, Charles Frey; *Tr.*, Henry Clement; g. 4-8½; 45 lb.; 1 mi.; storage bats.

Hudson, N. Y.—Hudson Electric Ry. Co.—*Pr.*, H. McGonigle; *Sec.*, E. J. Hodge; *Tr.*, S. D. Loke; 3 mi.; g. 4-8½; 30-50 lb.; 4 m. c.; overhead cond. THOMSON-HOUSTON.

Lafayette, Ind.—Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2¼ m.; g. 4-8½; 27-35-52 lb.; 9 m. c.; 9 Sprague cars. SPRAGUE.

Lakeside, O.—3 mi.; 2 c.; overhead cond.

Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi. g. 4-8½; 56 lb.; 10 m. c.; storage bats.

Louisville, Ky.—Central Pass. R. R. Co.—*Pr.*, B. du Pont; *Sec.*, J. C. Donigan; —— mi; g. 5.

Lynn, Mass.—Lynn & Boston Ry. Co.—*Pr.*, A. F. Breed; *Tr.* and *Clerk*, E F. Oliver; *Supt.*, L. C. Foster; g. 4-8½; overhead cond. THOMSON-HOUSTON

Manchester, Va.—Richmond & Manchester Ry. Co.—*Pr.*, J. E. Taylor; *V Pres.*, J. Bryan; *Sec.* and *Treas.*, Jackson Brandt; *Supt.* B. R. Selden; 3½ mi.; g. 4-8½; 38 lb.; 10 m. c., 10 Sprague cars; overhead cond. SPRAGUE.

Minneapolis, Minn.—Minneapolis St. Ry. Co.—*Pr.*, Thos. Lowry; *Sec.* and *G. M.*, J. E. Rugg; *Treas.*, M. B. Koon; *Supt.*, D. W. Sharp; *Eng.*, E. T. Abbott; 69½ mi.; g. 3-6; 27-35-45 lb.; 8 m. c.; overhead cond. SPRAGUE.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g, 4-8½; 52 lb.

New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*, E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.

New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g 4-8½; cond. conductor. BENTLEY-KNIGHT.

North Adams, Mass.—Hoosac Valley St. Ry.—*Pr.*, W. B. Baldwin; *Sec.*, S P. Thayer; *M.*, H. A. Fitzsimons; 5 mi.; g. 4-8½; 40 lb.; 5 m. c.; overhead cond. THOMSON-HOUSTON.

Omaha, Neb.—Omaha Motor Ry. Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 5 mi.; g. 4-8½; 56 lb.; 20 m. c.; sta. 250 h. p.; over head cond. THOMSON-HOUSTON.

Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.

Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.

Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, F. H. Skeele; *Sec.*, E. H. Cook; *Tr.*, C. D. Newton; *V. P.*, M. Dillon; *Supt.*, T. M. Burt; 3 mi.; g. 4-8½; 38 lb.; 5 m. c.; overhead cond. DAFT.

Reading, Pa.—Reading & Black Bear Ry.—1½ miles; 2 m. c.; overhead cond SPRAGUE.

Revere, Mass.—Lynn & Boston R. R.—Ocean Ave. line; overhead cond. THOMSON-HOUSTON.

Richmond, Va.—Richmond City Ry. Co.—*Pr.*, J. L. Schoolcraft; *Treas.*, Walter Kidd; *M.*, C. M. Bolton; *Supt.*, Charles Selden; 7½ mi.; g. 4-8½; 30-40 lb.; 50 m. c.; overhead cond. SPRAGUE.

Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.

St. Joseph, Mo.—Wyatt Park Ry. Co.—*Pr.*, J. M. Huffman; *Sec.*, I. R. Williams; capital, $300,000; 5 mi.; g. 4-8½; 10 m. c.; overhead cond.; 8 Sprague cars. SPRAGUE.

St. Louis, Mo.—Lindell Ry. Co.—*Pr.* J. H. Lightner; *Supt.*, G. W. Baumhoff; *Eng.*, E. J. Bagnall; —— mi.; g. 4-10; 65 lb.; 1 m. c.; 2 m.; 3 p. c.; storage bats.

Sacramento, Cal.—Sac. Elect. Ry. Co. The Central Street Railway Co.—*Pr.*, L. L. Lewis; *Sec.*, E. K. Alsip; *Tr.*, F. Miller; *Supt.*, J. B. Austin; *Eng.*, ———; 13 mi.; g., 4-8½. Cars to be supplied by Electric Car Co, of America, Philadelphia.

Sault Ste. Marie, Mich.—S. St. M. St. Ry. Co.—*Pr.*, E. M. Lacy; *Sec.*, F. Ryan; *G. M.*, L. G. Cody; 2 mi. FISHER.

Sandusky, O.—Sandusky St. Ry. Co.—*Pr.*, Chas. V. Olds; *Sec.* and *Treas.*, A. C. Moss; *Supt.*, Clark Rude; 4 mi.; g. 4-8½; 32 lb.; 6 m. c.; overhead cond.; 6 Sprague cars. SPRAGUE.

Scranton, Pa.—The Nayaug Crosstown R. R. Co.—*Pr.*, E. B. Sturges; *Sec.*, A. Frothingham; *Tr.*, G. A. Jessup; *Supt.* and *Eng.*, T. Gibbs; 1-5 mi.; 4-8½; 52 lb.; 2 m. c.; steam power; sta. 250 h. p.; overhead cond. VAN DEPOELE.

Scranton, Pa.—The People's St. Ry.—*Pr.*, W. Matthews; *Sec.* and *Tr.*, H. E. Hayd; *Supt.*, F. Pearce; 10 mi.; g. 4-8½; 20 m. c.; overhead cond. SPRAGUE.

Seattle, Wash. Ter.—

South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; (Enos elevated railway); 8 mi. 40 and 56 lb.; 10 m. c.; track conductors. DAFT.

Springfield, Mo.—2 mi. FISHER.

Steubenville, O.—Steubenville Electric Ry. Co.—2¾ mi.; g. 4-8½; 40 lb.; 7% grade: 10 m. c.; overhead cond. SPRAGUE.

Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; *G. M.*, H. McGonegal; 4 mi.; g. 4-8½; 8 m. c.; 4 p. c.; steam power; sta. 250 h. p.; overhead cond. THOMSON-HOUSTON.

Wichita, Kas.—Wichita & Suburban Ry. Co.—*Pr.*, G. C. Strong; *Supt.*, O. J. Chapman; (contract for 2 miles); 7 mi.; 30-40 lb.; 3 m. c.; overhead cond. THOMSON-HOUSTON.

Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

RECAPITULATION.

Roads Now in Operation,	**43**
Roads Constructing or Under Contract,	**48**

Notes.

THE THOMSON-HOUSTON Co. will begin at once the construction of a line for the West End R. R. Co., Boston, from Harvard square, Cambridge, to Arlington, to be operated by the overhead system so called. Cars are to be in operation within 60 days, and as soon after the completion of this section as possible, work will be begun on a line to enter Boston as far as Bowdoin square.

THE SPRAGUE COMPANY, as will be seen in the above lists, have followed up their success at Richmond, Va., by taking a number of contracts for the equipment of electric street railways in various parts of the country.

IN NEW YORK STATE the Third Ward Railway Co., of Syracuse, have contracted with the Thomson-Houston company for the complete equipment of four miles of road with the overhead system and the construction of eight motor cars. This company contemplates extensive additions, and there is no doubt but what the city will soon possess one of the finest electric roads in the United States. This road will be in operation the first of October, and nearly all the work has already been completed.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From August 21 to September 18, 1888 (inclusive).

Alarms and Signals:—*Electric Signaling*, C. Ader, 388,008, August 21. *Circuit-Closer for Call Systems*, C. E. Dey, 388,344. *Fire-Telegraph*, J. H Guest, 388,357. *Automatic Fire-Telegraph*, 388,358. *Circuit Changing Device for Burglar Alarms*, F. H. Nutter, 388,488. *Thermal Circuit-Closer for Fire-Alarms*, H. S. Petit and H. S. Bresson, 388,505. *Electric Fire-Alarm Signal Box*, S. A. Chase, 388,631, August 28. *Electric Bell*, M. G. Crane, 388,836. *Electric Annunciator*, C. H. Crockett and C. C. Allen, 388,837. *Electric Signal*, H. T. Hill, 388,869. *Magnetic Annunciator*, W. Humans, 388,876, *Electro-Magnetic Bell*, same, 389,080. *Device for Actuating Street or Station Indicators*, W. A. Turner, 389,122, September 4. *Electro-Mechanical Gong*, J. P. Tirrell, 389,423, September 11. *Fire-Alarm System*, T. G. Turner, 389,678. *Telegraphic Call for Messengers, &c.*, B. Dubinski, 389,839, September 18.

Clocks:—*Electric Motor for Self-Winding Clocks*, F. W. Brainerd, 388,622, August 28.

Conductors, Insulators, Supports and Systems:—*Underground Electric Conduit*, E. H. Phipps, 388,442. *Electrical Conductor*, W. A. Conner, 388,477. *Suspending Overhead Electric Wires*, A. E. Harris, 388,487, August 28. *Electric Conductors and Process of Uniting the Same*, C. McIntire, 389,314, September 11.

Distribution:—*Electrical Distribution by Secondary Batteries*, T. P. Conant, 389,638. *Means for Distributing Electric Energy*, S. Z. Ferranti, 389,795 and 389,838, September 18.

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THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS.

PUBLISHED MONTHLY AT

11 Wall Street, New York City.

TERMS OF SUBSCRIPTION.

United States and Canada,	per annum,	$3.00
Four or more Copies, in Clubs (each)	"	2.50
Great Britain and other Foreign Countries within the Postal Union	"	4.00
Single Copies,		.30

[*Entered as second class matter at the New York, N. Y., Post Office, April 9, 1888.*]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed*, EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall Street, New York city.*

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VOL. VII. NEW YORK, NOVEMBER, 1888. No. 83.

SOME REMARKABLE VIEWS IN ELECTRICITY.

PERHAPS the old time "lightning-rod man" with his hollow conductors, will soon be found to have been nearer the truth than the incredulous electricians who reviled his notions as to proper conductors for the safe conveyance to earth of violent electric discharges. This thought, along with others of more significance closely related to it, comes to mind on the perusal of Professor Lodge's abstract of the electrical papers read at the September meeting of the British Association for the Advancement of Science, which we reprint in other columns of this issue.

At the outset Professor Lodge indulges in a little suave merriment, as several other observers have done, at the expense of those members of the Association who may be called engineers rather than instigators or theorists; but, his brief fun over, settles down to a most interesting and suggestive account of the electrical papers in Section A (Mathematical and Physical Science), at the Bath meeting.

The practical or engineer class of electricians will find much material for reflection and incentive to experiment in the abstracts given of several papers relating to the general question of electric conduction, and in Professor Lodge's comments upon them, taken in connection with the "Lightning Rod Discussion," the general outcome of which latter, as summarized by Professor Lodge, we print in parallel columns.

Very special and practical interest attaches to the views of Sir William Thomson, Professor Lodge, and others, in respect to the conduction of oscillatory currents, either rapidly alternating or rapidly fluctuating. Their experiments lead to the conclusion, which they express with much confidence, that the passage of such currents is confined more or less closely to the surface of a conductor, the depth of penetration depending upon the rate of alternation or change; the lower the rate the deeper the penetration, till in a steady current it reaches the entire mass.

This view is of the utmost significance in respect to alternate current distribution. Indeed, Sir William Thomson, assuming 150 complete alternations per second to be the rate now employed in practice, reckons the depth to which the currents penetrate the conductors at three millimeters, and thinks that the conductors should be tubes or flat bars.

This theory of conduction, of the highest importance to the electrical engineer if verified in practice, is closely related to the more recent views on the nature of electricity and its relation to the all but demonstrated ether, or universal medium or substance, and is particularly interesting in connection with the speculations and theories presented by Professor Lodge in his series of articles in *Nature*, on "Modern Views of Electricity."

A HEROINE.

UNCONSCIOUS heroism, in the performance of simple duty in the face of imminent peril on the part of one in humble position, stirs the heart of the beholder, if not the imagination, more deeply than the great deeds of great men done with the eyes of all the world upon them.

Miss Mamie Davis, of Jacksonville, Florida, an operator in the telephone exchange there, held to her post and her work when left entirely alone for a time during the yellow fever epidemic. We have by chance had the privilege of seeing a letter from one of her superiors, from which the following is an extract:—

"Mamie Davis has been sick to-day and has not been to the office, so I had to do operating and a little of everything; I do not think Mamie has any symptoms of the fever, but it is dangerous to get sick now. She had a very hard cold yesterday and complained of feeling tired. I told her to go home and I would do the operating, but she refused. Her brother said this morning that she had no fever, and would be back to-morrow.

"There is no doubt that if it had not been for her, the exchange would have been closed. At one time we were all down (including Manning) and for one day she ran everything by herself. * * * For some time she had been alone with Manning working from six in the morning till night, and eating her dinner at the board. She does not take any special credit to herself but says it was very sad and lonely, the only company being the calls, and most of them for doctors, undertakers and ambulances, and she was constantly expecting to hear that some one of us was dead. She and her little brother, a messenger boy for the telegraph company, support her mother and themselves. Her mother did plain sewing and rented rooms before the fever broke out, but since has not been able to earn anything. I sincerely hope she is not going to have the fever."

No word of ours could add a touch to the picture thus presented to the reader's mind of this heroic girl alone in the exchange, her luncheon in one hand, switch plugs and cords in the other, keeping up communication in the fever and panic-stricken city.

At the Twenty-third Annual Meeting of the American Society of Mechanical Engineers, held at Scranton, Pa., October 15–20, Mr. C. J. H. Woodbury, vice-president of the society, read a paper on Electric Welding, presenting a clear and interesting account of its principles, apparatus, process and applications, with some remarks on the strength of electric welds. The paper was supplemented by tables comprising the official record of tests made on the Emery testing machine at the United States Arsenal, Watertown, Mass., by the Ordnance Department, U. S. A. The tables include the results of tests of 78 welds. The metals were iron, steel, copper, brass and german silver; the bars being of a variety of sizes from one-quarter inch to four inches in diameter. The tables give the tensile strength and the position of the fracture. The fractures are reported as follows:—23 "at weld," 2 "at enlarged section of weld"; 4 "at or near weld"; 33 at varying distances from weld (that is quite clear of the weld or the enlarged portion); 16 are not reported.

Commenting on the results already attained in this new application of electricity, Mr. Woodbury says:—

"There is no reason why such a weld should be stronger than the rest of the bar, but if averaging of equal strength some of the breaks would occur at the weld."

"It will be readily understood, however, that as this process accomplishes many things hitherto impossible, aside from any question of ultimate strength, it is fitted for applications in many constructions where it saves labor and time; provided only that the joints be in all cases sufficiently good for the purpose for which the article is designed. A large field thus opens up in the execution of ornamental design in metal work, where it will supplant screws, rivets or solder for fastenings, and in other evident applications."

The announcement in regard to the testing of electrical instruments and apparatus in the physical laboratory of the Johns Hopkins' University, under the direction of Dr. Rowland, with Dr. Duncan and Dr. Liebig in charge of the tests, must prove of great interest to investigators, students and practical electricians. American electricians and the capitalists interested in the financial results of their work are becoming more and more appreciative of the value—not to say the imperative need—of accuracy in determining the quantitative elements involved in their apparatus and operations. Every facility for precise measurement means the possibility of saving money by cutting off wasteful expenditure.

In the unworldly precincts of scientific research and study, accuracy is prized for its own sake merely; and, from the scale of charges for tests promulgated in the circular of the Johns Hopkins' University, it may fairly be inferred that Drs. Rowland, Duncan and Liebig are far more greatly concerned for the promotion of trustworthy electrical work than for the enhancement of the University's revenue.

The Boston *Evening Transcript* points out an anticipation of the phonograph, by Jean Ingelow, who, according to an English writer, gave the world the idea of the invention in a story first published in "*Good Words*" (or one of the magazines bearing, Strahan's imprint) in 1872, and reprinted in the "Little Warderhorn." From a fairy tale called "Nineteen Hundred and Seventy-Two" the *Transcript* prints the following extract:—

He began to describe what was evidently some great invention in acoustics, which he said (confusing his century with mine), "you are going to find out very shortly. * * * You know something of the simple beginnings of photography?" I replied that I did. "Photography," he remarked, "presents a visible image; cannot you imagine something analogous to it which might present an audible image? The difference is really that the whole of a photograph is always present to the eye, but the acousticgraph only in successive portions. The song was sung and the symphony played at first, and it recorded them, and gave them out in one simultaneous horrible crash; then when we had once got them fixed, science soon managed, as it were, to sketch the image; and now we can elongate it as much as we please." "This is very queer," I exclaimed; "do you mean to tell me these notes and these voices are only the ghosts of sounds?" "Not in any other sense," he answered, "than you might call a photograph the ghost of sight."

A telegram from Pittsburgh, October 30th, printed in the New York papers of 31st, announces that the Westinghouse Electric Co. "has been awarded the contract for a plant to light the City of London, England. It will be the largest plant in the world." This contract is with the Metropolitan Electric Supply Co., Limited whose prospectus was noticed in these columns in September last; a company proposing to engage in supplying electric light from central stations on a large and comprehensive scale in the English capital. The present order is understood to be for a 25,000 lamp outfit.

It is a matter of congratulation that American enterprise has succeeded in meeting and vanquishing sharp and persistent home competition in supplying London with an electric plant of such magnitude as that to be furnished by the Westinghouse company.

His Honor, the present Mayor of New York, never misses an opportunity to put himself on record in respect to the overhead wire question. We have several times directed the attention of our readers to his felicitous and humorous sallies in the Board of Electrical Control. The following episode is reported as occurring at a meeting of the Board of Estimate and Apportionment, a few days ago:—

General Newton said it would cost $4.00 each to remove the 40,000 telegraph poles to be removed next year.

"Well, gentlemen," Mayor Hewitt said, "will any of you move an appropriation of $160,000 for that purpose?"

There was no response.

"Then, gentlemen," said the mayor, blandly, "I hope the reporters will note the fact, you leave me powerless to remove the poles."

"Deutscher Fernsprechvielfachklappenschrank" is the neat little trade name of the multiple switch-board proposed for use in Germany by a distinguished continental scientist.

If "An Old Subscriber," who wrote us September 5, will kindly send us his address, we will take pleasure in responding to his enquiry.

OBSERVATIONS.

A FEW days ago a minister of the gospel, by way of an illustration, spoke of the "*potentialities of the church for good.*"

What he meant was simply the "possibilities, etc." Isn't it one of the dearest prerogatives, and proclivities, of the natural man to use a big word which means something, in preference to a little word which means the same thing; especially when we have reason to believe that our hearers may possibly find their understanding of our big word a little shadowy? It is immensely gratifying to be able to fling out a word that is rather darkly significant.

And this little human weakness must be held accountable for the glibness with which the unthinking, as well as the thinking, electrician talks learnedly about "potentials" and "capacities," too frequently, we fear, without a very clear idea of what they really are.

As for the word "potential;" of course, for the most part, our practical electricians have a clear and accurate idea of its meaning and scope, as being the representative of possible power; of wound-up energy, so to speak; and when applied to electricity, as standing for its power and readiness to do work; but it is a good word for the charlatan, and he works it. "Potential," as used ordinarily, and representing the *difference* of potential" between the electrical condition of a particular body or point and the earth, or between two bodies or points, was introduced into electrical terminology in the year 1828; its first appearance being in a book entitled, "An Essay on the Application of Mathematical Analysis to the Theories of Electricity and Magnetism."

For a long time it hung fire, but when used, was employed as being an elegant and sonorous word, by a few writers, and chiefly as a synonym for tension and electromotive force. It stands very well for the first, but differs from the last, as Mr. Hering has well shown in his book.

. . .

GEORGE GREEN, the writer of the book referred to above, is very little known now-a-days; he is not often mentioned, and when he is spoken of, is very likely to be miscalled. Professor Rowland referred to him in his opening address at the Electrical Conference in 1884, and called him *James* Green; perhaps confounding him for the moment with the Philadelphia worthy of that name, who wrote, in 1827, a work on Electro Magnetism.

George Green was born in Nottingham, England, July 14, 1793; and died March 31, 1841, at Swinton. Latimer Clark, speaking of his book, says "it is one of the most important works ever written on electricity;" and Fleeming Jenkin gives us a dissolving view of him in the opening lines of the second chapter of his book "Electricity and Magnetism."

. .

JACKSON, Miss., sends a despatch dated Sept. 25, to the Associated Press, relating to the yellow fever scare; one of its paragraphs was as follows:—"The best illustration of the fear of the people was received to-day, when a gentleman in the suburbs refused to receive a message by telephone, for fear of contagion."

. . .

TALKING of telephones brings to mind the reflection, that while the days of the four Georges, whom Thackeray loved so well, are long gone by, the "Young Pretender" is as vigorous as of yore. And if, as is frequently the case, the pretender, young, old or middle-aged, be an exploiter or inventor of a new telephone, the record of his prototype of the Georgian era is, by comparison, paled, as he goes on to tell that his instrument will talk. To modify Captain Cuttle's statement of the capacity of his watch—"It will talk: Lord; how it will talk." A specimen of this class was recently interviewed by a scribe connected with a Boston newspaper, and in sounding the praises of his very own telephone (which, by the way, was of the so-called acoustic or mechanical variety), said, and said in all seriousness, "*I can attach one of my telephones to one end of the Atlantic cable, another to the other, and talk without any trouble.*"

Certainly; but why go to the formality of attaching the telephones? The gentleman conservatively said nothing about hearing; that evidently being quite a secondary consideration. Yet when we read the above-mentioned statement, we are forcibly reminded of the boast of the biggest boy in the nursery, who alarms his mother, and fills his brothers and sisters with awe, by declaring that he can "put two chairs back to back, and then take off his shoes and jump over them."

. . .

THE way of the transgressor, it is to be feared, is being made easy. Electricity is no respector of persons, but benefits the just and the unjust alike. It has been utilized in many benevolent ways, and now as a change we have a patented invention, which to judge from its name may be an invaluable aid to the bunko man. It is one entitled a "Tester for Card *Flats*" and was issued from the Patent Office in September of this year.

Famishing Frank and Thirsty Pete have long laid snares for Hezekiah Dewtell and Samuel Buttermilk, but not until now have the latter named gentlemen been obliged to present themselves for examination as to their fitness for plucking.

This business being chiefly carried on in New York, it would seem fitting that if Mayor Hewitt's renomination result in his re-election, he should turn his attention to devising apparatus for the "protection of card flats;" whereupon the pleasing young card *sharp* who "knew your father when he was *so* high, Sir," will, in one particular at least (his occupation being a negative quantity), resemble the swarthy Moor who married and smothered Desdemona.

. . .

ONE observes that the unit and word-making fiend has once more begun his ravages, and that we are now to be regaled with "kines," "boles" and "barads." If this goes on much longer, we shall have to make a new Volapük, for the old one won't be able to grapple with it. But what can be expected after all, from a generation which not only swallows but likes "cablegram," that most hideous etymological mule.

A message received at New York from San Francisco, which travels through a multitude of river cables is a telegram; but a message by telegraph from London received at San Francisco is a cablegram; in the name of common sense why not "telegram" for all?

. . .

PERHAPS we shall have "phonogram" domesticated next; and if we are going to do that kind of thing we may as well go the entire figure.

Apropos of phonograms and phonographs, let it be noted that a literary phonograph has just been constructed by the gifted author of "Mr. Isaacs." This phonograph is a book entitled "With the Immortals;" Mr. F. Marion Crawford's idea of resuscitating the minds and souls of such immortals as Julius Cæsar, Pascal, Dr. Johnson, Heine, and others, is not so new as to entitle him to a broad claim, but it is well elaborated, and suggests a not unfavorable comparison with Walter Savage Landor's "Imaginary Conversations." Mr. Crawford has, one thinks, some trouble in catching the souls of Cæsar, Heine and Pascal, and in making them talk naturally; but his phonograph copies with considerable skill the oracular utterances which seem naturally to fall from the lips of the great lexicographer.

. .

A DOG cart has been built in London by a firm of unbelieving giaours, and fitted with an electric motor made by Immisch & Co., of London, for the Commander of the Faithful himself, Abdul Hamid Khan, Sultan of Turkey. It cost $1,000, carries four persons, and is said to closely resemble in general appearance a regular British dog cart.

If his majesty's esteemed predecessor, the late Abdul Aziz, had been asked even to ride in a dog cart, his horrified cry: "Is thy servant a dog, that he should do this thing?" can easily be imagned.

But Turkey as well as the sun "do move."

ARTICLES.

A POCKET GALVANOMETER.[1]

BY AIKITU TANAKADATE.

(Assistant to the Professor of Physics, Imperial University, Tokio, Japan.)

§I. COILLESS POCKET GALVANOMETER.

If a permanent magnet be fixed by an axis through its magnetic axis, it will be perfectly restrained from responding to external magnetic influences. But if the magnet be fixed by an axis which is only parallel to, and not coincident with its magnetic axis, it will still be in neutral equilibrium in a uniform magnetic field. In other words, a magnet so supported cannot be distinguished from non-magnetic bodies whatever be the strength of the field so long as this remains uniform; induction being neglected for the time.

If one or any number of small bar magnets be vertically attached to a suspended piece of wood, or if a horseshoe magnet be hung by a string, as in figure 1, such a system may be realized. The astatism is quite independent of the number of magnets, as each several magnet is in neutral equilibrium.

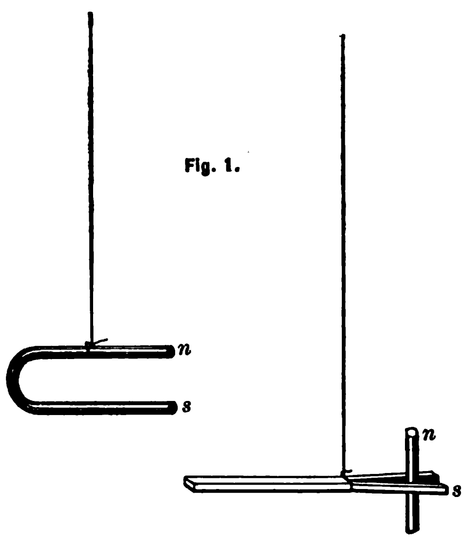


Fig. 1.

In such a state of equilibrium, if a pole of another magnet, or a wire conducting a current be brought near, the first magnet will be pulled or pushed as the case may be, so as to rotate round the fixed axis; the only necessary condition being that the forces acting on the two poles of the magnet shall be unequal, as will generally be the case in the neighborhood of a straight conductor. The circumstances of rotation will depend upon the strengths of the magnet and of the current respectively.

Any small portion of a closed electric circuit may be looked upon as the edge of a large magnetic shell. Now, if two opposite poles of a small magnet be placed close to the edge of such a shell at equal distances from the edge, the electro-magnetic force acting on the magnet will be constant, provided the line joining the two poles always passes through the edge of the shell, no matter how the other portions of the shell may lie with regard to the magnet. If four poles in rigid connection be placed about such an edge, it will be possible to find such an arrangement of the poles that the force acting on the system of the poles will be sensibly constant when the edge is within a certain portion of space between the four poles.

Thus it becomes possible to construct an instrument which will measure the strength of such a shell without breaking its continuity, and that independently of the uniform field in which the shell may be situated. That is, an instrument which will measure the current without breaking the circuit and which can be used in any position and in any uniform field. This is the idea upon which the apparatus to be described is constructed. It is indeed simply a modified form of an astatic galvanometer.

The following is one particular form of the apparatus:—Four small bar magnets are fixed symmetrically at the four corners of a thin rectangular plate of wood, which can rotate as a whole about a fixed central axis perpendicular to its plane and parallel to the magnets, as shown in figure 2. What we want to measure is the couple about this

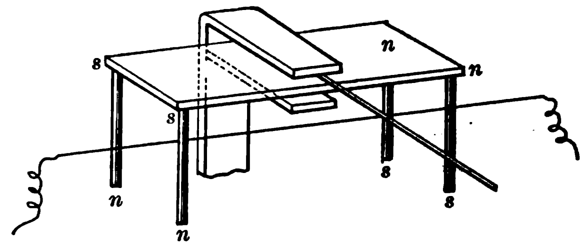
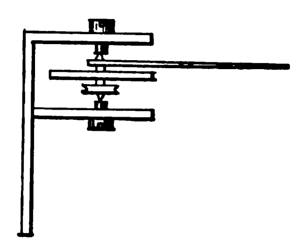


Fig. 2.



axis. We may accomplish this by means of two springs, one attached to the frame, the other to an index, and both springs initially stretch very much as in an ordinary aneroid barometer. The motion of the index is magnified by means of a multiplying lever introduced between the index and its spring, as shown in figure 4. As we cannot use steel springs, an alloy of gold and brass, which is used in making springs for *pince-nez* eyeglasses, answers here very well. Ordinary brass springs, however, are easier to make, although they are not quite so lasting.

The whole arrangement is then put in a case with a jaw-like vacant space hollowed out for receiving a conducting wire. The axis for the index projects above a graduated circular plate, and the index is fixed at right angles to the jaw, in such a way that when part of a circuit is slipped in within the jaw, the index will be moved toward that side to which the current is passing; in other words we may imagine the tip of the index to be carried by the current. The value of the indications depends upon the strengths of both the magnets and the springs, and has to be obtained by comparison with some standard galvanometer; and this calibration must be repeated occasionally as with other instruments of a similar description.

There is one inconvenience, however, in this system, namely, that the four magnets placed round the current have all their axes perpendicular to the direction of the current and consequently they are subject to the effect of induction. The induction will be positive for the two approaching magnets (that is their moments will be increased), and negative for the receding two. The total effect on the system will be nearly nil for small currents; but with large currents the magnets may be permanently affected and may even be reversed in magnetization. We can get rid of this inconvenience by fixing the four magnets to an axis which is perpendicular to each axis of the magnets, as in figure 3. It will be seen that the system is exactly the same as the previous one, if the four magnets be of equal moments or if they satisfy the condition $\Sigma M = 0$ with respect to the fixed axis. The former

1. From the Journal of the Science College, Imperial University, Japan. Vol. i.

condition we can not hope to attain in practice, but the latter can be approximated to thus:—

Make some 10 or 20 magnets of the same steel wire and leave them for some months or even for years, until the

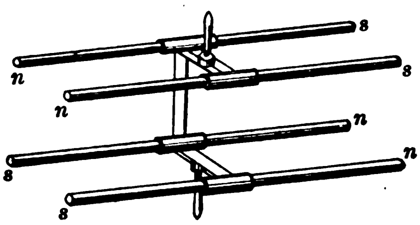


Fig. 3.

time rate of the fall of moments becomes insensible. Then measure the moment of each magnet by any of the ordinary magnetometric methods, such as the deflection of a mirror magnetometer at a constant distance from each magnet, a knowledge of the relative strengths only being essential. The magnets I used in one arrangement had the following relative moments.

(a)	(b)	(c)	(d)
313.3	311.7	312.0	313.0

This gives $(a) + (b) = (c) + (d)$ within the errors of experiment, an arrangement which was accordingly adopted. We may notice here, that if the determination of any one of them were in error of 1 in the unit figure, its uncompensated effect would be $1/\Sigma M = 1/1250$ of the whole.

In other details of construction this form of apparatus is exactly the same as the previous one, except that the jaw is side-wise instead of vertical. This gives a greater precision to the instrument as will be seen immediately, and still more facilitates the introduction of the coils of fine

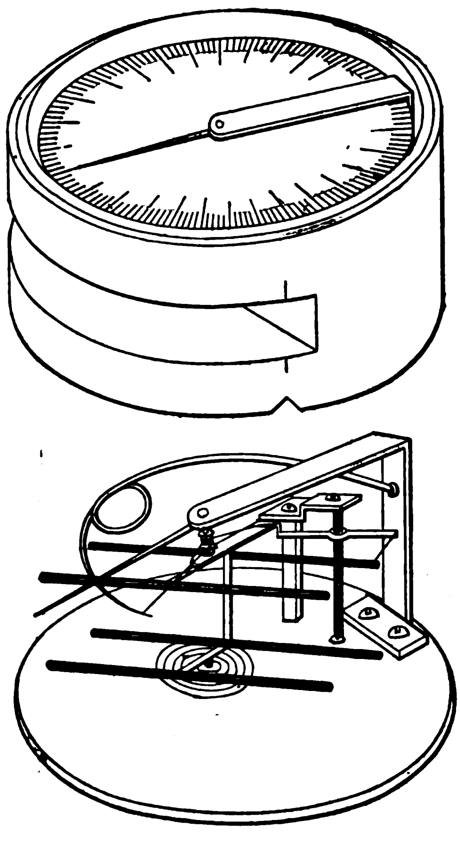


Fig. 4.

wire for measuring large differences of potential and small currents in the way to be described further on. The above cut shows one of the working instruments.

In calibrating the instrument, it is best to use a small current repeated many time instead of a single strong current, which is so difficult to keep steady. For this, 200 turns of a fine insulated wire were wound round in the form of a circular ribbon having a circumference of about 1 meter. The wires were tied together with a string so that the external appearance was like one thick insulated wire of circular section; one portion of this was put into the jaw, the remaining portions being as far removed as possible from the instrument. A current from 20 Daniell cells was passed through the ribbon; a standard tangent galvanometer and a resistance box being in the circuit. Simultaneous readings of the standard galvanometer and the pocket instrument were taken for different strengths of current, obtained by varying the resistance. From these the value of the current corresponding to 1 division of the pocket instrument was easily calculated. The following table gives the results of the comparison thus made with the working apparatus :—

Standard Galvanometer.		Pocket Galvanometer.	
Reading.	Reduced to amperes	Reading.	Value of 1 division in amperes.
12.0	.0350	12.4	.565
19.7	.0575	20.6	.558
28.9	.0844	30.5	.554
35.5	.1037	37.4	.555
		Mean	.558

As the instrument was graduated to 100 divisons we could measure with this up to 56 amperes, and, as will be seen later, by placing the wire below the instrument up to 168 ($= 3 \times 56$) amperes. In making the comparison, we must place the standard galvanometer at a considerable distance from the ribbon, which becomes a strong magnetic shell when the current is passing. In fact it is best to put the two instruments on different tables, and make two series of observations, one with the current direct and the other with it reversed. For measuring a moderate current, such as 1 or 2 amperes, we can advantageously repeat the circuit three or four times by simply coiling the conductor so as to make a temporary ribbon like that just described.

By altering the points of support of the springs (as in the time rating of a watch) we may, if it is required, adjust the instrument so as to make one division correspond to some simple fraction of an ampere, say .5 or .2

FIELD OF FORCE AND ARRANGEMENT OF MAGNETS.

In studying the field of force due to four magnets arranged as in figure 4, and a single straight conductor parallel to their axes, we have only to consider the action of a single straight conductor upon one set of four poles which lie in a plane perpendicular to the conductor, since the other set of poles is an exact counterpart of the one considered. As proved in Maxwell, the electro-magnetic force at an external point of a straight cylindrical conductor of infinite length depends only upon its distance from the centre of the section, for any concentric distribution of current; and since the action between a magnet and a current is mutual, if a compound cylindrical magnet consists of concentric layers of uniform intensities, its action upon an externally placed current running parallel to the axis of the magnet, must be reducible to the action of a single equivalent pole at its centre, whatever be the law of distribution of magnetism from layer to layer. As we make our magnets of cylindrical wire, and as most conductors are cylindrical, we may safely reduce the action to the centres of the sections of the magnets and the conductor, neglecting the pole-shifting effect due to the induction of magnets on each other.

Let $2a$ be the distance between like poles, and $2b$ that between unlike ones; and put r for $\sqrt{a^2 + b^2}$.

Let x, y be the co-ordinates of any point referred to the centre of the rectangle $[2a, 2b]$, measured parallel to a and b respectively.

Let ξ η be the co-ordinates of any one of the poles, referred to *any position of the current as origin*, so that if x, y be the co-ordinates of the current,

$$\xi + x = a \text{ and } \eta + y = b$$

Then $\rho = \sqrt{\xi^2 + \eta^2}$ is the distance of any pole from the current.

The potential energy of unit current and four unit poles is

$$V = 2\,\Sigma \tan^{-1}\frac{\eta}{\xi} + const. = 2\,\Sigma\,\theta + const. \quad (1)$$

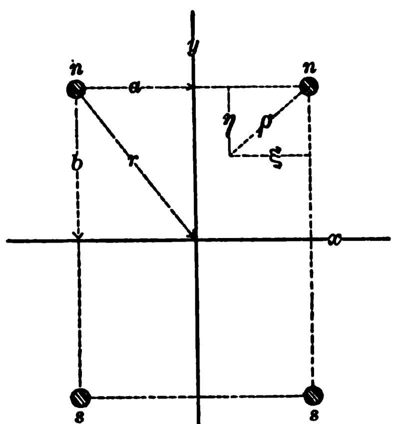


Fig. 5.

Σ meaning summation for the four distinct poles and θ being the angle between any of the polar distances and the axis of ξ. V then reduces to the algebraic sum of the two angles subtended by the two parallel lines of length $2b$ placed $2a$ apart. This is the same as the potential energy of unit pole and two parallel magnetic strips of infinite length placed $2a$ apart, the breadth of each being $2b$. The solid angles ω_1 and ω_2 of the usual notation become two spherical wedges. The two magnetic strips may be replaced by two equal pairs of parallel currents, placed along the edges of the strips, as will be evident *à priori*, since the action of a unit current upon four unit poles must be the same as that of four currents upon a unit pole so far as the dynamical aspect is concerned. This latter was the combination I used in making an experimental verification of the result.

From (1) the equation

$$\Sigma\,\theta = const.$$

gives the equi-potential surfaces, and

$$\Sigma \log \rho = const.$$

gives the lines of force. Figure 6 shows a special case of such a field.

To determine the best arrangement of the magnets so as to minimize the error due to the eccentric position of the current (which is the same thing as that due to the deflected position of the magnets) we may proceed to find the electro-magnetic forces acting upon the system of magnets, when the current is placed in any position, x, y. Putting F for this force and expanding it in terms of eccentric displacement δx, δy, we have,

$$F = F_0 + \frac{\delta F}{\delta x}\delta x + \frac{\delta F}{\delta y}\delta y$$

$$+ \frac{1}{|\underline{2}}\left\{\frac{\delta^2 F}{\delta x^2}(\delta x)^2 + 2\frac{\delta^2 F}{\delta x\,\delta y}(\delta x)(\delta y) + \frac{\delta^2 F}{\delta y^2}(\delta y)^2\right\}$$

$$+ \frac{1}{|\underline{3}}\left\{\frac{\delta^3 F}{\delta x^3}(\delta x)^3 + 3\frac{\delta^3 F}{\delta x^2\,\delta y}(\delta x)^2(\delta y) + 3\frac{\delta^3 F}{\delta x\,\delta y^2}(\delta x)(\delta y)^2 + \frac{\delta^3 F}{\delta y^3}(\delta y)^3\right\} + \cdots\cdots$$

where F_0 is the force at the origin. On account of the symmetry of configuration, the terms containing odd powers of either δx or δy vanish when taken for all the four magnets. The equation then reduces to

$$F = F_0 + \frac{1}{2}\left\{\frac{\delta^2 F}{\delta x^2}(\delta x)^2 + \frac{\delta^2 F}{\delta y^2}(\delta y)^2 + \frac{\delta^4 F}{\delta x^4}(\delta x)^4 + \cdots\cdots\right\} \quad (2)$$

where $$-F = \frac{\delta V}{\delta x} = \frac{\delta}{\delta x}2\,\Sigma\,\tan^{-1}\frac{r}{\xi}$$

but since $$\left.\begin{array}{l} x = a - \xi \\ y = b - r \end{array}\right\}$$

$$\frac{\delta^n}{\delta x^n} = (-1)^n\frac{\delta^n}{\delta \xi^n}$$

$$\frac{\delta^n}{\delta y^n} = (-1)^n\frac{\delta^n}{\delta \eta^n}$$

$$F = \frac{\delta}{\delta \xi}\Sigma\,\tan^{-1}\frac{\eta}{\xi} = \Sigma\,\frac{-\eta}{\xi^2 + \eta^2}$$

also $$\frac{\delta^n}{\delta \xi^n}\left(\frac{\eta}{\xi^2 + \eta^2}\right) = \frac{(-1)^n\,|\underline{n}\,\sin(n+1)\,\theta}{(\xi^2 + \eta^2)^{\frac{n+1}{2}}}$$

$$\frac{\delta^n}{\delta \eta^n}\left(\frac{\eta}{\xi^2 + \eta^2}\right) = -\frac{(-1)^n\,|\underline{n}\,\sin(n+1)\,\theta}{(\xi^2 + \eta^2)^{\frac{n+1}{2}}}$$

$$\tan\theta = \frac{\xi}{\eta} \qquad \text{as before}$$

Thus, taking only the increment of force, we get from equation (2)

$$\Delta^2 F = -\,\Sigma\left(\frac{\sin 3\,\theta}{\rho^3}\delta x^2 - \frac{\sin 3\,\theta}{\rho^3}\delta y^2 + \cdots\cdots\right)$$

but when δx and δy are each small ρ becomes very nearly r, and θ may be regarded as measured from the centre of the rectangle $[2a, 2b]$. We may then dispense with the sign Σ in discussing the configuration. Thus if

$$3\,\theta = \pi \text{ or } n\pi$$

or $$\theta = \frac{\pi}{3} \text{ or } \frac{n\pi}{3}$$

the coefficients of $(\delta x)^2$ and $(\delta y)^2$ vanish simultaneously. In other words if the magnets are arranged occupying any four opposite corners of a regular hexagon, that is if a/b be nearly $4/7$*, the error due to a small displacement will be eliminated up to the third order of the displacement inclusive.

The simultaneous disappearance of the coefficients of $(\delta x)^2$ and $(\delta y)^2$ might indeed have been anticipated from the general equation $\Delta^2 V = 0$ since V is here function of only x and y we have

$$\frac{\delta}{\delta x}\Delta^2 V = \frac{\delta^2}{\delta x^2}\frac{\delta V}{\delta x} + \frac{\delta^2}{\delta y^2}\frac{\delta V}{\delta x} = 0$$

now $\delta V / \delta x$ is F. Hence when either of $\delta^2 F / \delta x^2$ or $\delta^2 F / \delta y^2$ vanishes the other must do so too.

The uniformity of the field arrived at by this arrangement is shown by the following diagram of equi-potential lines and lines of force. Curves representing the intensities of forces along the co-ordinate axes and the diagonal are also given.

FIELD OF FORCE.

$$a^2 : b^2 : r^2 = 1 : 3 : 4.$$

*Practically it will be found better to make a/b somewhat larger than $4/7$, so to obtain a greater range of uniformity in the field.

The general expression for the force is

$$-F = \frac{\delta}{\delta x}\, 2 \, \Sigma \tan^{-1} \frac{\xi}{\eta}$$

$$= 2 \left\{ \frac{b-y}{(b-y)^2 + (a-x)^2} + \frac{b-y}{(b-y)^2 + (a+x)^2} + \frac{b+y}{(b+y)^2 + (a-x)^2} + \frac{b+y}{(b+y)^2 + (a+x)^2} \right\}$$

If, now, we make

$$\left.\begin{array}{l} x = 0 \\ y = 0 \\ \rho = x\dfrac{a}{r} = y\dfrac{b}{r} \end{array}\right\} \text{successively}$$

we obtain the expressions

$$\left.\begin{array}{lll} F = \dfrac{8\,b\,(r^2 + x^2)}{(r^2 + x^2)^2 - 4\,a^2\,x^2} & \cdots\cdots(\alpha) & \text{along } x\text{-axis} \\ F = \dfrac{8\,b\,(r^2 - y^2)}{(r^2 - y^2)^2 + 4\,a^2\,y^2} & \cdots\cdots(\beta) & \text{“ } y\text{-axis} \\ F = \dfrac{4\,b\,r^2}{r^4 + r^2\,\rho^2 + \rho^4} + \dfrac{4\,b}{r^2 - \rho^2} & (\gamma) & \text{“ diagonal} \end{array}\right\} \text{respectively.}$$

The maxima and minima of these are given by

$x = 0$

$x = \pm \sqrt{r\,(-r \pm 2\,a)}$ .... (α')

$y = 0$

$y = \pm \sqrt{r\,(r \pm 2\,a)}$ .... (β')

$\rho = 0$

$\rho = r$ (others being imaginary) ... . (γ')

from which we see that the pairs of maxima are superposed at the origin if $r = 2a$, which is equivalent to $\theta = \frac{\pi}{3}$. The minima along the y-axis at $y = \pm \sqrt{r\,(r + 2\,a)}$ are always real for any ratio of a/r. In the present case, the values become $\pm 2\sqrt{\frac{2}{3}}\,b$. Substituting this value of y in (β) we get the value of F there $= -\frac{1}{3} F_0$. It will be seen that at each of these points, the lines of force begin to change their curvature, and the field is sensibly constant. By constructing the instrument so that the base lies just above one of these points, we adapt it for the measurement of very strong currents, such as 100 amperes or greater. To facilitate such a measurement a **V**-groove is cut out along the base in the proper position, and into this the circuit bearing the current is received. To reduce the value thus obtained to what it would have been, had it been placed in the jaw, we have only to multiply the reading by -3.

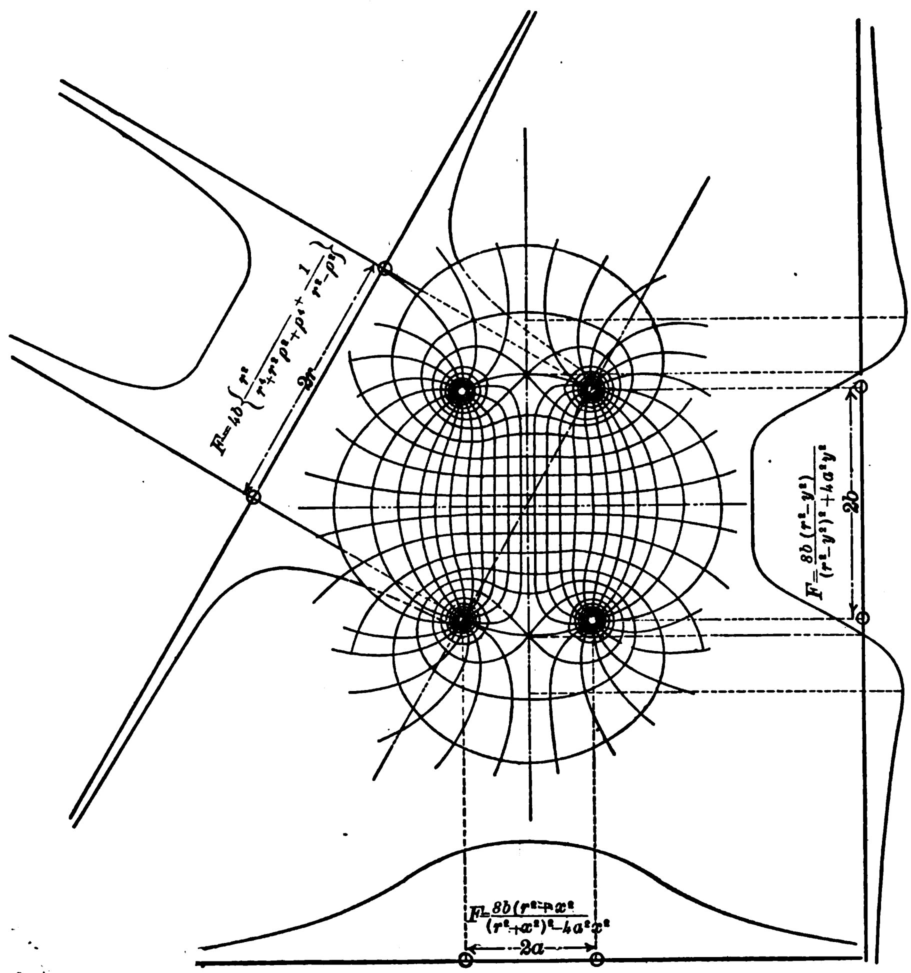


Fig. 6.

The following table giving the proportional decrement of force for given displacements of the magnets, will show to what amount of displacement we may, without sensible error, assume the uniformity of the galvanometer constant as obtained by calibration for small displacements. Computing $(F - F_0) / F_0$ we have

Along x-axis.		Along y-axis.		Along diagonal.	
$\delta x/a$	$\delta F/F_0$	$\delta y/b$	$\delta F/F_0$	$\delta \rho/r$	$\delta F/F_0$
1/4	1/4161	1/4	1/435	1/4	1/445
1/3	1/1333	1/3	1/133	1/3	1/132
1/2	1/273	1/2	1/24	1/2	1/21
1	1/21				

As long as the deflection is within $\frac{1}{2}a$, the error will be less than 1/2 per cent. and when it is to the extreme limit of a, the error will be about five per cent. It is interesting to notice that δF is very nearly proportional to the fourth powers of δx, δy, $\delta \rho$, even when these are $\frac{1}{2}a$, $\frac{1}{2}b$, $\frac{1}{2}r$. The above table enables us to adjust the range of the index and the jaw of the instrument so as to keep the magnitude of errors within any assigned limit. In the actual instrument constructed the width of the jaw was $\frac{1}{2}b$, and the deflection was limited to $\frac{1}{2}a$, so that the error fell within $\frac{1}{273}$ for any reading, even if we suppose the eccentricity in the direction of y to be as much as $\frac{1}{4}b$.

To verify the results thus far obtained the following experiment was made in the Physics Laboratory of the Science College of the Imperial University:—Six blocks of wood, each 21 cm. high and 13 cm. wide were arranged in a row upon a long laboratory table extending through a space of 3.7 meters along the magnetic meridian. These blocks served simply as guides for the stretching of two rectangular coils of insulated wire, whose distance apart bore to the height of either the ratio required (tangent 30°). Each coil consisted of six turns. Thus were obtained two parallel magnetic strips of practically infinite length.

One of Thomson's graded galvanometers with its field magnet taken away, was placed in the space between the two central blocks, its V-groove lying along the magnetic east and west line. The height of the galvanometer was so adjusted that the centre of the four small magnets, belonging to the fan-shaped compass, was always in the plane half way between the upper and the lower lines.

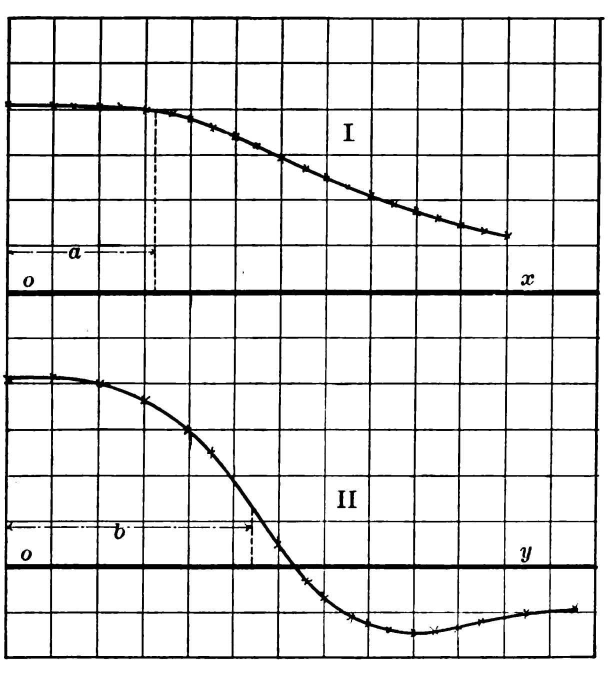


Fig. 7.

A current was run round the wire and was left for about 20 minutes till its flow became steady, and then the compass was slid along the V-groove, and its position and deflection simultaneously observed at several positions. From these observations the curve I, in figure 7, was obtained. By a slight modification of the arrangement, providing a vertical V-groove, the compass was made to move along a vertical line; and from a similar series of observations the curve II was obtained. These should be compared with the curves of figure 6.

It will be seen that the system of magnets thus arranged is equivalent to Helmholtz's galvanometer of two circular coils, if we imagine the two coils to be deformed into two long rectangles of infinite length, that is, reduced to four parallel currents. For if we adjust these currents to proper positions, and replace each of them by a magnet and the central magnet by a straight current, we have the system just discussed.

(To be continued.)

SOME OBJECTIONS TO THE OVERHEAD CONDUCTOR FOR ELECTRIC RAILWAYS.[1]

BY M. B. LEONARD.

Of all the valuable papers read before the Institute, probably none has excited greater interest than Mr. Sprague's admirable contribution on "Electric Railways the Solution of the Municipal Rapid Transit Problem," in which the advantages of electricity in practical operation have been so well set forth as to convince the most skeptical of its superiority over all other methods of traction for this class of traffic. Although the paper was written with special reference to the adaptability of electricity in solving the problem of rapid transit in the great City of New York, the benefits resulting from this system of propulsion may be obtained equally as well elsewhere, and prove to be as permanent as we have found them in our historic City of Richmond.

To electrical engineers this comparatively new application of the electric current is one of the most important questions that have come before them, and should be carefully studied in all its details, so that the defects and objections may be pointed out and provided against, and the most perfect methods devolved as speedily and fully as possible. But in working this question out it must be remembered that "the most haste, the less speed," and that before undertaking to surpass the locomotive it is wiser to prove its superiority over the horse or mule. Having accomplished this successfully, then it is time to endeavor to rival steam. In attempting what has been aptly described as "feats of sensational engineering," it should always be borne in mind that failure inevitably deals a severe blow to the whole cause of electric traction, the general public not always inclined to discriminating in such cases, as will be remembered from the accident which occurred to a number of capitalists and prominent people some years ago, who were engaged in testing the traction system of a well-known electrician.

A second point of the utmost importance is the necessity for first-class workmanship. Anything worth doing at all is worth doing well, and particularly is this the case with the utilization of a new force. This is so self-evident as to require no further comment.

While it has been successfully demonstrated in the City of Richmond that electric traction is really the solution of the rapid transit problem, and we have felt, in the increased value of real estate and the growth of our city in population and reputation, the substantial benefits resulting therefrom, I have considered from my daily observation of this electric road that the overhead wire system cannot be made a perfect or ideal method of operation under all circumstances, because of the defects inherent in such a method. But that it will serve as a pioneer in the new

1. Read before the American Institute of Electrical Engineers, New York October 9, 1888; in discussion of Mr. F. J. Sprague's paper on The Solution of Municipal Rapid Transit, read before the Institute June 19.

field and will be supplanted in time by a more perfect system, I have not the least doubt; and in the following remarks I will endeavor to show some of the objections that have come to my notice, although there may be others that have escaped my attention, owing to the extreme reticence of all parties connected with the enterprise, doubtless from business reasons.

Of the three most commonly used, the overhead system appears to be the favorite. The latest report of electric street railways in operation in America shows that out of a total of 43, not less than 36 are using the overhead system and that at least 30 now under construction have arranged to do so. Doubtless the smaller cost as compared with the other two was an important factor in deciding so largely in favor of the overhead conductor.

As used in Richmond, the details of operation have been shown so fully and clearly in Mr. Sprague's paper that it is unnecessary to repeat them here, beyond stating that the rail and earth system is adopted in connection with the overhead wire.

During the seven months of active operation of the Richmond Union Passenger Railway, many thousands have been successfully transported every day and at a very much lower cost than could possibly have been done by horse-power, owing to the excessive grades encountered; but the defects of the overhead system are now becoming more apparent as the plant suffers its material depreciation, and we are now in a better position to judge of its value as a permanent institution than we could possibly have done heretofore.

It is an undisputed fact that the encumbering of the streets with the poles required for the overhead system is one of the most serious objections to its use, although they are hid to a large extent in many places by the shade trees and foliage, yet on the main streets of our cities where this system is most likely to be used they are not only a grievous eyesore but also increase the liability to accident from runaway horses and other causes. Their appearance would not perhaps be so offensive were it possible for them to maintain an erect position, but on account of the weight of the trolley wires, and the pressure of the trolley, the tops of the poles are constantly pulled together notwithstanding they may have at first been raked in the other direction, and thus the unsightly effect is augmented.

Those of us who are acquainted with telegraph line construction, can appreciate the great leverage exerted by a heavy strain on the top of a pole 25 or 30 feet high, unsupported by guys or otherwise, and will readily understand that it is only a question of time before the poles must be reset or replaced with heavier ones. This has been especially the case on the curves where the strains have been greatest, in some instances approximating a pull of 650 lbs., nor does the network of wires, span, trolley, guard and curve, inspire the public with any feeling of toleration for the disfiguring of its streets, but must hasten the time when the clamor for underground wires will compel their removal.

But to my mind the most serious objection is the employment of the bare trolley wire carrying a current of 500 volts and about 90 amperes, which I consider not only dangerous to life on account of the frequent breakage of the wire, which on one occasion last spring in falling struck and killed a horse, but also in damage to property by fire. It is claimed that the use of guard wires will always prevent the possibilities of such an occurrence, but the guard wires did not obviate the burning and melting of the telephone wires when on one occasion the breaking of an exchange telephone pole threw them across the trolley wire, and it was necessary to shut down the railway to prevent the entire destruction of the exchange and possibly the firing of the subscribers' instruments and houses.

That the trolley wire is liable to breakage at any time has been shown twice during the past week to the interruption of travel and dissatisfaction of the public. While not so very long ago the wires over one of the curves were pulled down on top of the car by the trolley catching in it, and travel entirely suspended on that part of the line for one or two days.

A very serious defect in the use of the bare trolley is the difficulty of securing proper insulation. Thus far porcelain knobs seem to have been found best adapted for this purpose; and the leakage resulting, especially in damp or rainy weather, must be considerable on the whole length of the line, and must cause a large waste of current. This is probably the reason why it has been impracticable to run over about 30 cars at one time out of the 40 with which the road is equipped, and would seem to indicate a very large loss of energy.

In view of the fact that porcelain insulators have been long ago condemned for telegraph purposes where a comparatively small current is used, it seems strange that they should have been adopted as the best means for securing insulation in circuits of such high potential as are employed on the Richmond road.

The trolley itself seems to be a clear source of trouble and difficulty to manage properly. As has been shown, it consists of a grooved wheel at the end of a counterbalanced pole held by a spring against and making contact with the under side of the working conductor. In rounding curves it must be carefully watched by the car conductor to prevent it leaving the trolley wire and thus stopping the car, and at night extinguishing the lamps, which has proved exceedingly disagreeable to the passengers, while on busy days it has seemed necessary to put a third man on at each car at additional expense for the sole purpose of attending to the trolley. Sometimes the trolley pole has broken or the springs holding it against the wire given way, stopping further progress of the car or requiring a man to stand on the car roof holding the trolley pole against the wire until the repair sheds were reached.

One of the most unsatisfactory features about the arrangement of the Richmond road is the ground circuit, not only because of the difficulty of getting a good ground, which has in this case only been accomplished by connecting the track with the whole gas or water works system of the city to the detriment of our exchange telephone system (so well described by the telephone superintendent, Mr. McCluer in his paper before the recent telephone convention), but the fact that it is necessary to have a clean track to work on; otherwise vivid flashes of electricity will appear, to the terror of the horses in the vicinity and damage to the motor, or should it happen that there is a sufficient quantity of dirt on the rail it will cause a higher resistance than the potential of the current can overcome and, of course, stop the car. Should the motor man get off to push it over the dirt and fail, as sometimes happen, to switch off the current from the motor, the full current on the line will pass through it just as soon as a good contact is made and the result is a burnt armature and a disabled car. This seems to have been particularly the case during the recent stormy weather, when I am imformed that the number of available cars for traffic on the road was reduced to about ten. Possibly the saturation of the motor by the rain and the effect of lightning on the trolley wire had also something to do with the case. Owing to the reticence of the employés above referred to, it has been difficult to ascertain just what damage has been caused by lightning striking the trolley wires and injuring the motors, but that there has been serious trouble from this source, I have no doubt. The very best forms of lightning arrestors have not proved sufficient to prevent injury to electric light dynamos where insulated wires are used on the outdoor circuits, while the bare wire used for the working conductors on overhead electric traction systems must always render them more susceptible to trouble from this direction.

After setting forth the difficulties which have been shown in the practical operation of the most extensive system of electric traction in the world, it gives me pleasure to direct

attention to the remarkable behavior of the Sprague motors under all the conditions to which they have been subjected for the past seven months, which has been indeed remarkable. No load has been too heavy and no grade too steep for them to ascend. Perhaps the severest test they ever received was on the night of July 4th, in bringing the crowds from the new Reservoir Park, when the ordinary open cars carried over 100 passengers and the closed cars over 75 each, so many in fact that the axles of one or two of the cars broke down under the load; all of which must be exceedingly satisfactory to the inventor, and places the Sprague motor at the very head of the many excellent types or forms that have been devised at home and abroad.

The objections referred to above apply equally as well to all forms of overhead systems, except where a second wire is used for a return instead of the track and earth, and also where the trolley pole is discarded for the movable trolley. But the increased number of aerial wires required as well as the heavier fixtures needed to sustain them render these systems just as objectionable.

We are very anxious to see the effect of ice, sleet and snow upon the operation of our road, as it has not yet passed through a winter in complete running order. A heavy sleet storm has often prostrated our telegraph lines, and I see no reason why the overhead electric railway wires would be exempted from similar trouble, nor why the covering of the rails by ice and snow will not render it difficult to make a sufficient contact to operate the line successfully, not to speak of the loss of current by leakage or escape from the trolley wire; but I have no doubt that the ingenuity of those who have overcome all the problems encountered in opening up with such success The Richmond Union Passenger Railway, will be sufficient to insure its continued operation in spite of wind and weather, and to no one more than myself, will this be gratifying, since it was through my efforts that attention was first directed some three or more years ago, to the splendid opportunities for electric traction that Richmond presented, although I am free to confess that my inclinations were towards the application of the storage battery, which obviates all the troubles and defects developed by the overhead systems, and against which no more serious objections seem to be brought than the extra weight caused by the batteries and the greater first cost as compared with the aerial systems, all of which, it appears to me, are more than counterbalanced by the difficulties and annoyance in the systems just described.

The very satisfactory results obtained in the operation of the new electric storage cars on the Fourth avenue railroad in this city, as well as by Mr. Wharton, of Philadelphia, Mons. Huber in Brussels, and elsewhere, prove, as I have believed, the storage battery to be the only ideally perfect system of electric traction for municipal purposes.

NOTE ON GEARING FOR ELECTRIC RAILWAY MOTORS.[1]

BY ALMON ROBINSON.

PROBABLY no one will be disposed to deny that in devising a connection for the motor and the car wheels, what Mr. Sprague attempted to do, has been done extremely well. Has he attempted all that is desirable?

Mr. Sprague's investigations have shown that, in street car work, a very large percentage of the whole power used is expended in starting the cars. Now it seems to me, that a motor whose speed has a fixed ratio to that of the car wheels must work uneconomically when the car is moving slowly, for no amount of skill spent in varying the magnetic circuit can prevent an armature from wasting a current sent through it when it is practically standing still. It would seem, therefore, that wide variations of speed and load would make it necessary at times to weaken the field to an uprofitable extent.

1. Read before the American Institute of Electrical Engineers, New York, October 9, 1888.

Perhaps, however, Mr. Sprague may be able to show that a properly designed motor will work with a high efficiency in doing anything which he puts upon it in railroading.

But, even in that case, there would still remain the extra cost and extra weight of a motor large enough to lift its heaviest load by a dead pull.

To do the hardest part of his work, Mr. Sprague is really using a thing in which he disbelieves—a slow moving motor.

In the storage car problem this matter of weight, bulk and cost, becomes the most important element. Here, the present practice is simply: The hauling about of ten men to do by main strength what one man could do by a lever.

The desirability of a variable leverage for the motor has not escaped the attention of experimenters. In Mr. Henry's Kansas City work, an arrangement of toothed gearing and clutches was tried. I have never learned whether this particular feature proved a help or a hindrance; nor whether it is in use on the Henry road said to be running at San Diego, Cal. A prominent inventor has expended a good deal of ingenuity on the details of a plan making use of reciprocating friction pawls. Mr. Reckenzaun tried and abandoned a leather covered chain, clamped between two cones in such a way that the diameter of the circle of contact could be varied.

Mr. Van Depoele has suggested, and I presume, tried a connection having two different speed ratios, in which friction gears were used. For this particular purpose (furnishing a variable speed ratio) I am obliged to confess myself a believer in the possibilities of frictional gearing.

For electric railroad work, it is certainly under a cloud at present. Those who have used it most, like it least. The eminent engineer, who, about a year ago, read a paper before the Institute on "Methods of Gearing," seemed to consider that it had been sent to its last resting place by the experts who tested some of Professor Fleeming Jenkin's devices.

No one seems to notice that every day, and on every railroad this method of transmission gets the roughest possible testing; that every locomotive pulls its train by frictional adhesion; that a rail and driving wheel are neither more nor less than a frictional rack and pinion. When we try to copy the work of the locomotive under other conditions our troubles begin. But no man who has ever seen a freight engine climb a grade has any right to speak with disrespect of frictional gearing.

The real root of all the difficulties with frictional transmission seems to be that the pressure producing adhesion does not vary with the dimensions of the gearing; so that when we reduce the size and increase the speed of the gearing the friction at the journal bearings soon becomes enormous. For light work this is partly obviated by using, instead of metal, some more adhesive material, such as paper, rawhide, etc. But none of these surfaces will stand a pull at all comparable with that on the surface of a locomotive driving wheel.

The most promising methods would appear to be those in which the pressure is prevented from acting across the bearings. This idea is carried out to some extent in the well-known V-grooved gearing; but the unavoidable sliding and grinding of the surfaces makes it impossible to obtain a high duty from it. The idea is more fully carried out in the devices of Sillers, Jenkin, and others. I do not know that anything has been suggested—I certainly cannot suggest anything—which does not leave, for the purpose under consideration, much to be determined by trial. Knowing well the effect which actual trial is apt to have upon untried devices, I cannot blame an engineer who prefers to let well enough alone, if a fixed speed ratio is all that he cares for. But I cannot help thinking that a usable connection, which left the speed of the motor independent of that of the car, would be a valuable acquisition; and that a probability of obtaining it would amply justify further experiments with methods of gearing.

ELECTROLYSIS OF TIN SALTS.[1]

BY ALEXANDER WATT.

(*Continued from page* 481.)

HAVING obtained these results, the solution was next strengthened by the addition of more tin salt, about five grains to the ounce, without increasing the proportion of hydrochloric acid. Figure 4 represents the crystals obtained from the solution thus modified, the curved or semi-circular cathode again being used with the current as before from one Daniell cell. Subsequently the solution was still further strengthened by adding an increased proportion of tin salt, with also a slight addition of hydrochloric acid. The results obtained from this modification are shown in figures 5 and 6, and it will be noticed what a marked difference there is between the latter examples and either of those preceding them. Indeed, from my experiments it became evident that a very slight modification in the strength of the electrolyte, or of the form of the cathode, was sufficient to cause an immediate change in the character of the crystallization, without any altera-

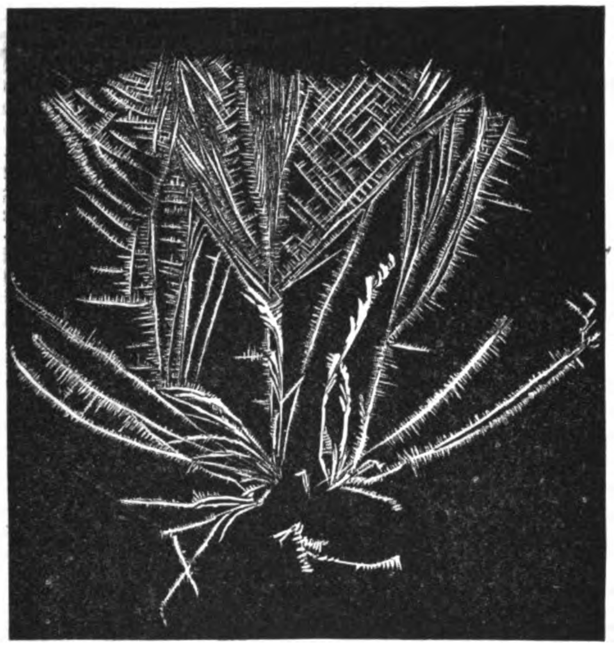


FIG. 4.

tion being made in the strength of the current. When, however, the current was increased by the addition of a second cell, this appeared to have less influence on the form of the crystals than was evidenced by increasing the metallic strength of the solution.

An attempt was next made to obtain a reguline deposit of tin from a solution of the protochloride by trying the liquid at various degrees of dilution, but it was found to be practically impossible to prevent the metal from depositing in a spongy condition unless the cathode was kept constantly in motion while in the bath. In this way, in a very weak solution, the metal could be induced to assume the reguline form, but for any practical purpose of electro-deposition a bath prepared from the protochloride of tin appears to be totally unsuited.

2. *Bichloride of tin.*—This salt was obtained by dissolving granulated tin in nitro-hydrochloric acid, and the concentrated solution thus obtained was afterwards added to water, in varying proportions, with the object of obtaining, if possible, a reguline deposit of the metal. The first bath was composed of two fluid drachms of the concentrated solution of the bichloride of three ounces of water, and the current from a single Daniell cell was employed. On immersing a brass plate in this solution, and a very small anode surface, a white film of tin was promptly obtained, and continued to retain this appearance for some minutes, but in about a quarter of an hour the film assumed a darkish color, and the deposit became pulverulent. The solution was next diluted with three more ounces of water and a fresh plate immersed, while the anode surface was also reduced. The deposit, as before, was very prompt, and of a fine white color, which it sustained for about 15 minutes, when the film gradually acquired a gray tone, due, as in the former case, to the deposited metal assuming the powdery form, though not in so marked a degree as in the first case. The bath was next again diluted by adding two more ounces of water—making eight ounces in all—and a freshly prepared brass plate put into the solution, the anode surface being still further reduced until the immersed surface was about one-eighth of that of the cathode. The deposit, though slower than in the former cases, was sufficiently rapid for a good coating, while the film was exceedingly white and perfectly reguline, which conditions were maintained for a much

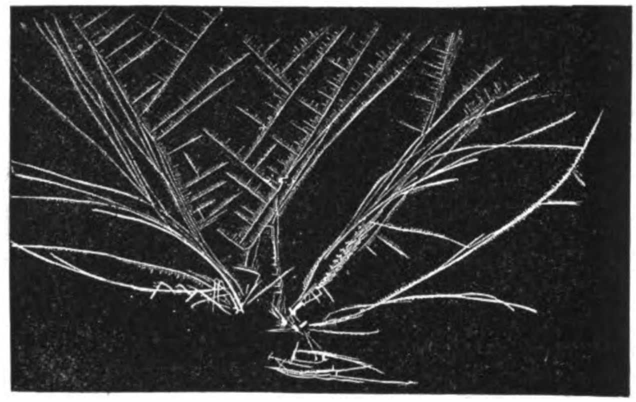


FIG. 5.

longer period than before. Eventually, however, the deposit at the lower part of the cathode assumed a gray color, and a spongy mass of the reduced metal appeared at each corner of the plate. A gelatinous mass (doubtless stannic acid) also formed in the solution, and floated on its surface in large clots. Further dilutions of the solution were subsequently tried, but it soon became evident that unless the cathode were kept in constant motion, no considerable thickness of tin, in a reguline condition, could be obtained from this solution. It was also found to be difficult to obtain crystals of the metal from solutions of the bichloride. A strip of zinc was immersed in the bichloride solution for some hours, at the end of which period it was found that this metal had deposited the tin in the form of stannic acid, which, being filled with bubbles of gas, floated on the surface of the liquid to the depth of about one inch.

3. *Tartrate of potassa and tin.*—A bath was prepared by digesting recently precipitated stannous oxide in a boiling solution of cream of tartar, for which purpose two ounces of the tartar were dissolved in 16 ounces of boiling water; an excess of

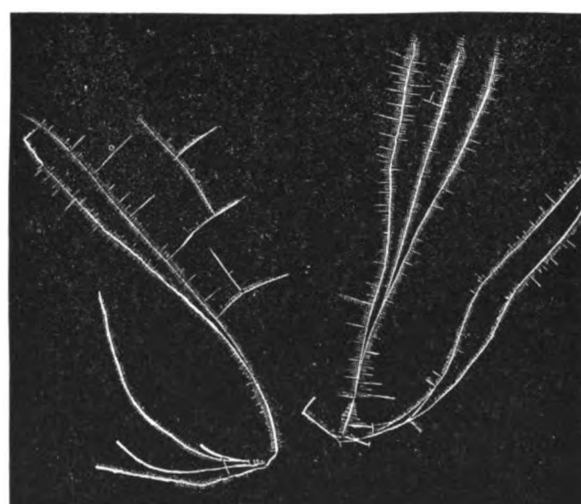


FIG. 6.

the tin oxide was then added, and the whole well stirred and kept hot for about an hour, after which the vessel was set aside to cool, when the clear liquor was decanted for use. With the current from a single Daniell, a white and bright film of tin gradually formed upon a brass cathode, but this assumed a pearly appearance after a few moments. The anode surface was about equal to that of the cathode, and there was no evolution of hydrogen. At the end of about two hours the plate had received a fairly good coating of metal, which was uniformly homogeneous and of good white color. It was noticed that the anode kept perfectly clean in this solution.

(*To be continued.*)

.... FOR long distances the transmission of energy is at present out of the question.—*W. H. Preece.*

1. From the *Telegraphic Journal and Electrical Review* (London).

LIGHTNING.[1]

BY S. A. VARLEY.

(Continued from page 495.)

In an earlier part of this paper I made reference to certain experiments carried through by me to ascertain the law which induction followed. The method I adopted, and the results obtained with flat plates, and also insulated circular conductors, were described in detail in a paper read before the Society of Arts in March, 1859, and published in their transactions. In the course of the description I state: "When a galvanic battery is connected with the inner and outer coatings of a Leyden arrangement, induction will take place through the dielectric, and if the surfaces of the two coatings are equal, then the force will be equally divided over them, that is to say, if the battery force be 100, the tension of the charge on the one coating will be 50, and that on the other will be 50 also = 100. Let the surface of the outer coating be infinite in extent, then the tension of the charge on the inner coating will approach infinitely near to 100, and the tension on the outer coating will be almost nil. An example of this we have when the earth represents one of the coatings of a Leyden arrangement, and this is the case in the prime conductor of a frictional machine, and also in the suspended wire of the telegraphic circuit. In these two examples the prime conductor of the machine and the wire of the telegraphic circuit represent the one coating, the air the dielectric, and the earth the other coating."

Assume a Leyden arrangement consisting of two metal plates, the surface of each of which say = 100, and the space separating them = 1.

If we charge one of these plates, which we will call No. 1, with negative electricity to, say a potential = 100, this negative charge will be balanced by a positive one on No. 2 plate having a + potential = 100.

Now reduce the surface of No. 2 plate to 10, and charge No. 1 plate as before with negative electricity to a potential = 100, this negative charge will be balanced by an equal amount of positive electricity on No. 2 plate; but as the surface of No. 2 plate is only $\frac{1}{10}$th that of No. 1, the positive electricity accumulated on No. 2 plate will be 10 times as dense as that of the negative charge, and therefore it will have a potential = 1,000, or to state it differently, it will have 10 times the force to break down the dielectric, and so bring about discharge.

If No. 2 plate were further reduced to a surface = 1, then the positive potential would be 100 times that of the negative charge accumulated on No. 1 plate, and if this negative potential, as assumed in the former examples, = 100, then the positive potential would = 10,000.

Here we have a simple explanation, which I think has been overlooked, of how it is that a needle point will discharge a charged Leyden jar through a very considerable space of air. If we could conceive a Leyden arrangement in which the metal plate of smaller surface was a mathematical point, it would be impossible to charge it, as the potential of a mathematical point would be infinitely great in all cases.

Now let us perform the experiment in a slightly different manner. Assume a second Leyden arrangement in which the surface of No. 1 plate = 1,000, the surface of No. 2 plate = 100, and the space separating the plates = 10. Assume that No. 1 plate has been negatively charged to a potential = 100.

The thickness of dielectric which will now have to be broken down for discharge to occur will be 10 times that of the first example, where the space separating the positive and negative plates = 1, and the surfaces of both plates were equal to one another; but as in this case the negatively charged surface has been increased to 10 times that of the positively charged surface, the positive electricity will be 10 times denser than the negative charge, and consequently it will have 10 times the potential; in other words, 10 times the breaking-down power; so we see increasing the area of one of the inductive surfaces of a Leyden arrangement facilitates discharge between oppositely charged surfaces and produces in effect a similar result as diminishing the space dividing them. The experiments above described harmonize with the electro-magnetic experiment referred to in an earlier portion of this article, where a soft iron core was wrapped with two sets of convolutions of insulated wire; and, further, these experiments, I think, throw light on the *modus operandi* of a Winter's ring when mounted on the conductor of an electrical machine, the action of which, as far as I know, has never been clearly explained.

When considering phenomena associated with electricity of high potential, such as that developed by a Wimshurst influence machine, the part which the dielectric itself plays should not be overlooked. Atmospheric air, as is well known, is a very perfect insulator; but, at the same time, it is a mobile one, and capable of having currents set up in it; moreover, there is always more or less matter in a fine state of division suspended in it, which acts the part of a carrier, and by electrical attraction forms a continuous chain of more or less semi-conducting material, which helps to electrically bridge the space separating oppositely charged surfaces, and when the tension is sufficiently high, I am disposed to think actual electrolysis, or certainly something approaching to it, occurs. I have already pointed out that two platina plates, separated by an electrolytic liquid, are a Leyden arrangement with a dielectric of low resistance, requiring a low electric potential only to break up its organization, and that what we see actually occurs in such a Leyden arrangement enables us to comprehend what electricity of very high potential is striving to bring about in the matter composing dielectrics, such as glass or atmospheric air. In a Leyden arrangement, formed by platina plates in an electrolytic liquid, we have oxygen in a condensed form adhering to one of the platina plates, and hydrogen, also in a condensed condition, adhering to the second plate.

If with the aid of electrolysis we despoit platina in a fine state of division on the platina plates, so as to cover their surfaces with minute angular or pointed particles, the adhesion of the oxygen and hydrogen to the platina will be very much reduced, and the gases developed by the disorganization of the dielectric will leave the electrodes as fast as produced. I am not aware of any explanation of this well-known fact having been attempted. I, therefore, venture to suggest one which is simple and harmonizes with other observed electrical phenomena.

When smooth plates are employed continuous sheets of the condensed gases are deposited on them and held there by cohesion, but when the surfaces consist of numerous small pointed particles, these projections become coated with the oxygen and hydrogen not in continuous sheets, but in minute detached masses similarly electrified, electrical repulsion between them therefore occurs, and the cohesive force which held the gases in the case of the smooth plates is overcome. The smooth plates of continuous surface act analogously to what is observed when soft iron cylinders and solid metal rods are employed for electro-magnets and electrical conductors, and the platina surfaces consisting of numerous angular particles act analogously to what is observed when a bundle of fine iron wires and a bundle of copper wires are employed for electro magnets and electrical conductors. I attach importance to such harmonies which seem to me to stare one in the face, and are to be found in every direction if we only look out for them, because they act as finger posts pointing out the direction for research, and they also enable us to criticise and often to correct detached and imperfectly observed phenomena.

When we have two wires suspended in the air, and highly charged with opposite electricities, the atmosphere dividing them is in a high state of electrical polarization, and the oxygen and nitrogen probably also become condensed and adhere to the oppositely charged conductors much in the same way as that observed in the case of polarized plates in an electrolytic liquid. We have evidence of what is here suggested in the production of ozone wherever electricity is being developed by influence machines.

It is, of course, well known that polarized metal surfaces will develop currents by reaction, and a similar but much more rapid reaction must occur immediately after the discharge through the atmosphere of highly excited conductors, especially in those whose surface and length is great relatively to their mass, and I venture to suggest that what I have called attention to may help to account for some phenomena observed by Professor Lodge in the course of his experiments. Mr. Wimshurst informs me that if bare wires be suspended in the atmosphere, and charged by one of his machines in a darkened room, the surface of the wires will be seen to have become luminous throughout, and dotted over with innumerable bright stars, showing an active transmission of electrical energy is taking place through the atmosphere. He also informs me the same phenomena are observed, but in a less degree, with suspended wires coated with gutta-percha, unless the coating be a thick one, in which case no such appearance will be visible.

In the continuation of my remarks in the next issue of this journal, I propose to make the few comments on Professor Lodge's experiment which I feel permitted to do, and to say a few words on the subject of lightning discharges and lightning conductors.

Before making a few comments on Professor Lodge's lectures on the protection of buildings from lightning, I wish to correct an error in the last issue. A Leyden arrangement is there described whose negatively charged surface is assumed to = 100 and the positively charged surface on the other side of the dielectric to = 10, and I state the positive electricity will, under such conditions, be 10 times as dense as the negatively accumulated electricity on the larger surface. It is then stated in error that the positive charge will have 10 times the breaking down power. What I ought to have said was 10^2 times the force; for the power to break through the dielectric increases as the square of the density of the charge, harmonizing in this respect with the heating effect of an electric current passing through a conductor and also with the breaking down energy of a rifle ball whose penetrating power is as the square of the velocity; which is intelligible enough when we reflect that a rifle ball moving with twice the velocity of another one, will have twice the energy; and as it is traveling at

1. From the *Telegraphic Journal and Electrical Review* (London).

twice the speed, this two-fold energy is given out in half the time when an obstacle is met with in its path, and consequently the crushing effect or power to penetrate becomes increased four times.

The practical value of Professor Lodge's lectures, and also the articles on "Modern Views of Electricity," seem to me to have been impaired from too much importance being attached to hypotheses and speculations, which are reasoned upon as if they were established truths on which further hypotheses may be safely founded; the consequence is that the bases on which Professor Lodge develops his views become more and more involved as he proceeds, until the subject being dealt with gets involved in such an inextricable and complicated mass of purely hypothetical assumptions, treated as indisputable facts, that I find it almost impossible to follow the reasoning, much less to accept the conclusions ultimately arrived at.

The following passages, extracted from part ii., chapter 4, under the heading "Energy of Currents," will, I think, speak for themselves.[2]

"We must learn to distinguish between the flow of electricity and the flow of electric energy, they do not occur along the same paths."

Further on it is stated: "Electric energy is not to be regarded as pumped in at one end of a conducting wire, and as exuding in equal quantities at the other; the electricity does indeed travel thus, whatever the travel of electricity may ultimately be found to mean, but the energy does not; the battery emits its energy not to the wire direct, but to the surrounding medium; this is disturbed and strained, and propagates the strain from point to point till it reaches the wire and is dissipated. This, Professor Poynting would say, is the function of the wire; it is to dissipate the energy crowding into it from the medium which else would take up a static state of strain and cease to transmit any more. It is by the continuous dissipation of the medium's energy into heat that continuous propagation is rendered possible." "The energy of a dynamo does not, therefore, travel to a distant motor through the wires, but through the air. The energy of an Atlantic cable battery does not travel to America through the wire strands, but through the insulating sheath. This is a singular and apparently paradoxical view, yet it appears to be well founded."

Further on we read, "How does the energy of the distant dynamo reach the car in this case, not *via* the wire connector; not even *via* the underground conductor. It travels from the distant dynamo through the general insulating medium between cable and earth. Some little enters the conductor and is dissipated, but the great bulk flows on and converges on the motor in the car, which is thus propelled. All the energy of the conducting wire is dissipated and lost as heat; it is the energy of the insulating medium which is really transmitted and utilized." This curious complicated hypothesis, which may possess a charm for those who love to indulge in the scientific uses of the imagination, and think the province of the scientist is to theorize, is referred to again in part iv. under the heading "Radiation," not as an hypothesis, but as an established truth, or at least as a completely demonstrated theory. We are here told "It is a curious function this of the telegraph wire; it does not convey the pulses, it directs them. They are conveyed wholly by the ether at a pace determined by the properties of the ether, modified as it may be by the neighborhood of gross matter. Any disturbance which enters the wires is rapidly dissipated into heat and gets no further; it is the insulating medium round it which transmits the pulses to the distant station.

"All this was mentioned in part iii., and an attempt was made to explain the mechanism of the process and to illustrate in an analogical way what is going on. The point of the matter is—currents are not propelled by end thrusts like water in a pipe or air in a speaking tube, but by lateral propulsion as by a series of rotating wheels with their axes all at right angles to the wire surrounding it as a central core, slipping with more or less friction at its surface. This is characteristic of ether modes in general; it does not convey longitudinal waves or end thrust pulses like sound, but it conveys transverse vibrations or lateral pulses like light."

We are also told in an earlier portion of the article:—"We already know of a continuous incompressible fluid filling all space, and we call it the ether."

The existence of such an entity is, of course, purely supposititious, and all that can be said for it is that with the limited powers we possess it helps us in some sort to group together and explain observed phenomena which we otherwise could not so well do.

I venture to think, if the dictum that science is disciplined common sense be not overlooked, we shall come to a different conclusion from that which Professor Lodge seems to have arrived at. The resistance of a conductor, and the transmission of energy through it, harmonizes in every respect with the transmission of force through a hydraulic system, and given uniform lengths and pressures the energy transmitted, be it electrical or hydraulic, is directly as the sectional area of the conductors and the pipes; this being so, common sense would suggest that the energy in both cases is transmitted in a similar way, viz., through the interior of the conductor as well as through that of a pipe. Such a view receives further support from the fact that electrical energy also harmonizes with mechanical energy; its power to break down resistance, as already pointed out, following the same law as that which governs a rifle ball when in motion.

In taking leave of "Modern Views of Electricity," I cannot help expressing my conviction that if the views there contended for be generally accepted by the rising generation, we of the older schools, who have accomplished some electrical work in the past, will not just yet have to retire to a back seat.

I now pass on to the consideration of lightning discharges and lightning conductors. In the autumn of 1856 it was my good fortune to witness a magnificent storm in Asia Minor, when riding from Mudania to the City of Brusa, a distance of 20 miles.

The valley of Brusa, on the outskirts of which we traveled, is the bottom of an oval crater or basin, whose major and minor axes are about 25 and 12 miles respectively. Our road, for the most part was a succession of hills, which we ascended and descended one after the other, and which, I have no doubt, had been formed by the breaking down of the crater walls.

Between 3 and 4 P. M. we saw the storm beginning to gather in the distance, followed shortly afterwards by a vivid flash, which seemed to shake the ground over which we were riding; the thunder that followed reverberated between the rocks and the sides of the crater, producing a metallic rattle altogether unlike any thunder I have before or since had experience of.

A deluge of rain followed the discharge, and the storm gathered in force, reaching its maximum a little after sunset, and continuing in full force for some hours afterwards. When the storm was at its maximum intensity, the lightning flashes succeeded one another so rapidly as to light up the road and enable us to pick our way through the mountain streams produced by the heavy rain, and through which we had to pass.

The lightning discharges followed each other in sets of three with almost monotonous regularity, and were confined to a limited and apparently circular area. We were then too close to the base of the mountain range to be able to see where the lightning actually struck, but as far as I could judge, they all seemed to strike the summit of Mount Olympus, which was the highest point, and nearly 7,000 feet high.

I have already stated the discharges were in sets of three, the second and third discharges were single angular sparks, similar to what we are familiar with in England, only they were heavier and more vivid. The main discharge was, however, altogether different from any lightning I have witnessed elsewhere; it reminded me of a crooked trunk of a tree bulging out at the top, and was not unlike a waterspout. I have since thought it might have been a mass of rain drops, aggregated together by electric attraction, and illuminated by the flood of electricity passing through it.

The summit of the mountain would be immersed in cloud, and formed in all probability a focus where a very rapid condensation of the clouds into raindrops was occurring, the discharges having their origin in clouds higher still.

Some few weeks later I ascended Mount Olympus, the summit of which I found to be a crater in a conical hill, rising about 1,000 feet from a plateau; the diameter of the mouth of the crater (as nearly as we could estimate) being about two miles or somewhat more than this, and I think it very probable the area of discharge was limited to the size of the crater. One side of the crater was broken down to the level of the plateau, and there was a frozen lake at the bottom of the basin out of which ice-cold water was flowing, forming a stream, in which trout were swimming.

There are two other cases of lightning discharges I would briefly refer to; the first of these occurred in Hyde Park, and was witnessed by my father when he was a boy. The lightning struck a broad graveled path, and a cloud of fire was seen to rise from the path and meet the flash in the air, My father ran to the spot where he thought the lightning had struck, but there were no signs of it anywhere to be seen; the graveled path, however, had the appearance as if fine sand had been recently sieved over it, producing a smooth surface, and there was a smell of ozone. There is very little doubt that the finer particles of the gravel were raised from the ground by electrical attraction, that the lightning discharge diffused itself throughout the suspended matter, and dissipated its energy over a surface of ground instead of boring a hole.

The second of the two cases occurred in a meadow in the immediate neighborhood of Epsom Downs. On either side of this meadow there were garden walls, and the space dividing them I estimate as being about 400 yards. In a garden immediately behind the wall on one side of the meadow there was a low tree, the branches of which extended over the wall, and during a storm which happened on an "Oaks Day" a man took advantage of the overhanging branches for shelter. A lightning discharge struck the wall on the opposite side to the one against which the man was resting, and knocked out some bricks; it then passed horizontally across the meadow striking the man (who was killed

2. See *Nature* of November 3, 1887, and August 23, 1888.

on the spot), destroying brickwork behind him, and disappearing without leaving any further trace. I did not see this discharge myself, but I visited the spot some weeks later, after the damaged brickwork had been repaired, and what I have related was described to me by an eye witness. The subsoil of Epsom Downs is solid chalk, some hundred feet in thickness, and I think the probability is that the tree was growing where it was because there was a fissure in the chalk which enabled the roots to extend downwards and to obtain sustenance, that this fissure was the path of least resistance, and the man having unfortunately placed himself in its immediate vicinity, he suffered in consequence.

In the lecture delivered by Professor Lodge on March 10, 1888, the following passage occurs: "Perhaps the best protected building in the world is the Hotel de Ville, at Brussels, the hobby of M. Melsens; the whole system used in this building is excellent and theoretically perfect, so far as I know, in every respect."

Faraday used to say facts stood before all theory; and I came across a passage in an evening newspaper of June 26, 1888, containing the copy of a telegram received from Brussels, which I annex: "A thunderbolt fell this evening upon the Hotel de Ville. A fire resulted but it was soon extinguished. A good deal of surprise has been occasioned, for the building was recently provided with lightning conductors made on a supposed improved principle, and which scientists declared would render this fabric perfectly secure against lightning; but the result has proved the contrary."

To say the least, it is very unfortunate that a costly and supposed perfect system should so signally fail within a few months of erection; I feel somewhat curious to know what was the subsoil on which the building is erected, and how the earth connection was made. I am disposed to believe that the surging of currents through lightning conductors to which Professor Lodge gives so much prominence is much more imaginary than real; at the same time, I can readily imagine that numerous conductors over a building may, under certain circumstances, be a source of real danger where there is an imperfect earth connection, for the electricity will then diffuse and dissipate itself wherever it can, and it will find its way to the earth by numerous more or less imperfect channels. It may be through conductors inside, and where such conductors are small or angular, through the atmosphere or through gas fittings, etc., and such vagaries as breaking its way through chimney shafts to the heated soot inside, or through a wall to a gun or fire irons, or a water tank, is, I believe, to be attributed primarily to the want of a good connection with the earth, and not to oscillations or surgings of the current in a conductor.

If a Leyden jar be discharged into a metallic chain lying on a table, sparks will frequently be noticed to occur between the links and the table throughout the length of the chain, because the table is an imperfect conductor; and a similar, but more powerful action of this kind is very liable to occur, also, in the case of buildings having lightning conductors not perfectly connected to the earth.

I am, however, of opinion that it is possible to protect a building from lighting with comparative facility, whatever may be the nature of the subsoil.

The usual system of proceeding in the matter of the protection of buildings is radically wrong, but it is not the fault of the constructor of the lightning conductor, who does the best he can under the conditions in which he finds himself placed.

In the earlier of the two lectures lately delivered by Professor Lodge, reference is made to a lightning discharge which struck St. George's, Leicester. The electric current is stated to have passed down the vane rod halfway down the spire, "where it blew a ring of stones out and so dropped the top half of the spire neatly inside the bottom half."

It is not mentioned whether this church had any lightning conductor, but I presume it was so protected. My chief reason, however, for referring to it is that it reminds me of a somewhat similar case which occurred at Doncaster, which was described, if I remember rightly, by Sir Edmund Beckett Denison The vane rod of Doncaster church passed through the crown of the tower, protruding some feet inside below the roof and terminating in the air. The conductor outside was connected at its upper end to the vane rod above the masonry. The lightning discharge struck the vane rod, and the electricity passed through it into the inside of the tower, leaping from the lower end of the rod through the air to the conductor outside, knocking out blocks of stone and bringing down a mass of masonry much in the same way as occurred at St. George's, Leicester.

I have observed a similar sort of action to what occurred at Doncaster in several instances where telegraph wires have been connected to a multiple protector. Figure 4 represents a top view of a 4-wire protector and figure 5 the same in elevation. Supposing No. 1 line has been struck and the discharge has passed across the air space separating the end of the terminal block marked A to the earth block E, which will be indicated by the burning of the metal in the neighborhood of the air space, it will be observed almost invariably that burning has taken place also on the opposite side at the end of the terminal block marked B. In some cases more or less burning will be observed to have occurred at the ends of all the terminal blocks, the chief burning taking place in a pair of the terminal blocks on the opposite sides. I have by me an example which I have preserved in which six out of eight blocks have been burned, the chief burning occurring in two places on opposite sides of the earth block. What I have now directed attention to would seem to indicate that a lightning discharge, possibly by setting up motion in the atoms

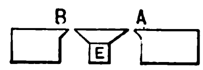


Fig.5.

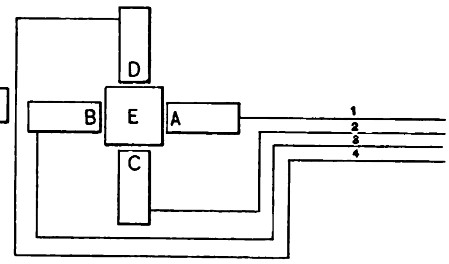


Fig.4.

composing the conductor, imparts momentum to them, and that the blow struck by the lightning at Doncaster threw the atoms of the vane rod into so rapid a state of motion as to break down the organization of the air and enable the electric discharge to pass through it and force out the masonry in its passage to the conductor outside.

To illustrate the views receiving the support of Professor Lodge, some very interesting experiments were performed at the second lecture, which are illustrated and described in the *Society of Arts Journal.*

The first of these is shown at figure 6, which has been copied from the *Journal*, containing the report of the lecture, and in reference to which it is stated: "The first form of experiment I have to describe is a very simple one. I call it the experiment of the alternative path; it consists in giving a Leyden jar discharge the choice between a certain conductor and a certain length of air, and in adjusting the length of air until it had lief take one path as the other.

"I am not aware that the particular mode of carrying out this simple experiment has any special significance; but to be definite, I depict the symmetrical arrangement I have most frequently, but not exclusively, adopted.

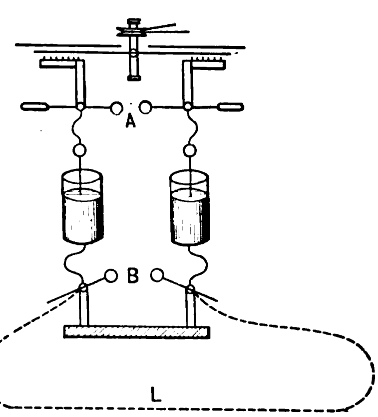


Fig.6.

"The knobs marked A are the ordinary terminals of a Voss machine, the jars stand on an ordinary wood table, and their outer coats are led to the discharger B, the distance of whose air space can be varied. The alternative path is shown by a dotted line. The discharge has to choose between B and L. Sometimes L is absent, and in that case the charging of the jars is quite well effected through the wood of the table; this is the advantage of having the jars imperfectly insulated. At the same time, the conducting power of the wood is too low to enable the jars to discharge themselves at all satisfactorily, unless the knobs, B, are within striking distance, or unless some path, L, is provided. The only discharge obtained at A, when both the paths, B and L, are absent, is a feeble spitting of intermittent and frequent sparking, very different from the loud report heard as soon as the knobs, B, are brought within striking distance. But it is not to be supposed that the B knobs must be as close together as the A knobs in order to permit complete discharge; on the contrary, the B knobs may be almost twice as far apart as the A knobs, and yet the charge may be complete and noisy.

"It will be understood that the two sparks occur together; a spark at A precipitates and is the cause of the spark at B; not *vice versa*, for until the A spark occurs there is not the slightest

tendency for a spark at B. The two B knobs are at the same zero potential, and may be touched with impunity except at the instant the flash occurs at A. Remember, the jars are standing on a common table all the time."

I confess that I cannot follow the reasoning from which it is concluded the spark, A, precipitates, and is the cause of the spark, B, not *vice versa*, but I pass on to the consideration of the results obtained, which I regard as much more important as well as more interesting.

Professor Lodge states: "The spark, A, was very loud whenever the spark was allowed to occur at B as well; but so soon as the discharge was compelled to traverse the alternative conductor, L, by putting the B knobs too far apart the noise of the discharge was much diminished, not merely because there is only one spark instead of two, but plainly because, for some reason or other, the discharge meets with considerable obstruction in the wire, whereby its duration is lengthened, and its noise, therefore, greatly lessened."

In the experiments described the length of the A spark was maintained at one inch, and as it was found convenient to measure the lengths in tenths of an inch, the A length was called 10.

The first alternative path consisted of 40 feet of No. 1 (B. W. G.) copper, suspended round the room by silk ribbon; and it was found the discharge refused to take this apparently easy path, and to persist in jumping the air gap, B, until the B knobs were separated 14.3 tenths of an inch, which was the critical distance, for when the B knobs were separated further apart the discharge chose the copper wire.

Now when a length of fine iron wire (No. 27, B. W. G.), whose resistance was 1,300 times as great as that of the copper wire, was substituted in its place, it was found that the distance separating the B knobs had to be reduced to 10.3 before the critical spark length was reached.

In other words, the discharge took place more readily through the fine iron wire than the much thicker copper one, a result (Professor Lodge says) that surprised him.

The summary of the results obtained with different sizes of copper and iron wires, the A spark length being 10 all the time, is given as below:—

Alternative paths.				Critical B spark lengths.
Stout copper wire,	No. 1 — R —	.025	ohms	... 14.3
Ordinary copper wire,	No. 19 — R —	2.72	"	... 13.4
Stout iron wire,	No. 1 — R —	.086	"	... 10.8
Ordinary iron wire,	No. 18 — R —	3.55	"	... 10.8
Thinned iron wire,	No. 27 — R —	33.3	"	... 10.3

Professor Lodge remarks in respect to the above: "The copper wires seem to obstruct almost equally, and the iron wires also obstruct equally among themselves, notwithstanding their very different diameters; but the coppers obstruct more than the irons."

Under the heading "Reason of the Enormous Obstruction offered by a good Conductor," it is stated: "Now what is the cause of all this astonishing obstruction offered by good conductors to the sudden rush of electricity?" One may express it in a popular way, thus: It is due to electrical inertia, or what is also called "self-induction." "A current cannot start in a conductor instantaneously any more than water in a pipe can start moving at full speed in an instant. Give the water a violent blow to make it move, it resists like a solid. The blow if very quick and violent may burst the pipe, but it will not appreciably propel the water, so in a manner is it with electricity. The flash occurs, and the conductor must either carry it off at once or not at all. There is no time to think about it, and the E. M. F. needed to overcome this inertia like obstruction is so great that a considerable thickness of air may be burst by it, and the discharge may flash off sideways to anything handy." Further on it is stated in this part of the lecture, there is another fact which it behooves us to be aware of. It is one to the importance of which the attention of scientific men has but recently been called. Experimentally it has been discovered by Professor Hughes, theoretically by Mr. Oliver Heaviside, Lord Rayleigh, and Professor Poynting; for though the necessary theory is really contained in Clerk-Maxwell, it required digging out and displaying. This has now been abundantly done, but the knowledge has scarcely yet penetrated to practical men; indeed, it has not yet been thoroughly assimilated by most physicists. The fact is this. When a current starts in a conductor, it does not start equally all through its section, it begins on the outside, and then gradually though rapidly penetrates to the interior. A steady current flows uniformly through the whole section of a conductor, a variable current does not. It is started first at the surface, and it is stopped first at the surface.

Remembering the rapidly oscillating character of an electric discharge, remembering also the fact that a rising current begins on the outside surface of a conductor, we perceive that, with a certain rate of alternation, no current will be able to penetrate below the most superficial layer or outer skin of the conductor at all. In the outer skin, of microscopic thickness, electricity will be oscillating to and fro, but the interior of the conductor will remain stolidly inert and take no part in the action.

Thus we arrive at a curious kind of resistance, caused by inertia in a roundabout fashion, and yet a real resistance, a reduction in the conducting substance of a rod, so that no portion except that close to the surface can take any part in the conduction of these rapidly alternating currents or discharges.

Now, notwithstanding the distinguished names mentioned, and who are credited with having theoretically and experimentally demonstrated that electricity (unlike water and other fluids) commences to flow through the outside of a conductor, I take leave to doubt it, and I express this opinion with the greater freedom, as I believe the correctness or incorrectness of these newer views can be determined by experiment. I may here state that, in conjunction with Mr. Wimshurst, I have tried some experiments to try and settle this point. These experiments are not yet completed; but they are so far positive, that they lead *me* to believe we shall at no distant date be able to confirm or refute what Professor Lodge seems to regard as determined already.

I have already said that I am not able to completely follow some of the reasoning having reference to the alternative path experiment, but I resist the temptation to say why I do so, because after all I should be expressing only my own views, and I do not set a high value on the views of any one (certainly not my own), unless they are backed by conclusive experiments, or harmonize with what we consider we really know. We can only reason from the known to the unknown, and in my own case, whatever scientific success I have been permitted to accomplish during the 56 years I have lived, I attribute solely to an early recognition of the harmony and parallelism which, as far as I can see, runs through *all* the phenomena of nature, and the simple fact which stares everyone in the face that be it a stream of people or a stream of water, the motion is observed to be more rapid in the centre would, if it stood alone by itself, be, in my opinion, an all sufficient reason for not believing that the flow of an electric current through a conductor commenced on the outside, and gradually penetrated to the interior, unless it was determined by absolutely conclusive experiments.

Although Professor Lodge has apparently convinced himself that electrical energy is not transmitted in a similar way to that of force through a pipe; nevertheless, when suggesting an explanation of the obstruction offered by good conductors to a sudden rush of electricity, he falls back upon a hydraulic simile.

The conductor forming the alternative path seems to me to somewhat resemble the musical wires which develop the lower notes of a pianoforte; these wires are in a state of tension, and would vibrate when struck at a rate that produces a comparatively high note, but being surrounded with spiral rings of heavier wire, the inertia which has to be overcome reduces the rate of vibration, and hence a lower note is given out.

When charging the jars in the alternative path experiment nearly the whole of the induction takes place between the inner and outer coatings of the Leyden jars at the earlier stage of charging, but as the charging proceeds, the induction which occurs through the air space of the A balls, and through the alternative path, increases; and as it is the air space separating the A balls where, practically speaking, the whole, or, perhaps, I should say, nearly the whole of the resistance occurs, the difference of potential is proportionately greater between the two A balls than at the two ends of the alternative path conductor, resembling, in this respect, a telegraph line of great resistance, in which the earth forms one half of the circuit. Now when the electrical potential becomes great enough to break down the resistance opposing discharge, the spiral rings of magnetism which are formed by the passage of the electric current through the wire, and which possess inertia, check the rate of the electrical pulsation much in the same way as the spiral metal rings surrounding a musical wire, and as the electricity set in motion refuses to wait, the air space separating the B balls, when not too far apart, opposes less resistance than the metallic conductor forming the alternative path.

I feel sure Professor Lodge would admit that further explanation is required to account for what was observed in his recorded experiments. Assuming, for example, that electricity commences to flow on the outside of conductors, why should not the current run down the outside of a copper wire as readily as outside an iron one; and why should copper wires of varying sectional area obstruct approximately equally, and also iron wires of different sectional area do the same? I myself am disposed to think that had the alternative path conductors been thickly coated with a good insulator the results obtained would have been found to be different from those recorded.

(To be continued.)

.... THE telegraphic system of England has been brought to the highest pitch of perfection. We have neither neglected the inventions of other countries, nor have we been chary of exercising inventive skill ourselves, and we have received our full meed of that reward which is always freely bestowed on a British government official—neglect and abuse.—*W. H. Preece.*

PROTECTION FROM LIGHTNING.[1]

In a previous article (see page 115 *ante Engineering*—page 496, Electrical Engineer), we dealt with the question of protection from lightning from the point of view of Dr. Oliver Lodge's recent researches, and the older experiments of Professor Hughes and Guillemin. As we mentioned at the time, the experimental results are to a certain extent contradicted by actual practice. If we were to be guided entirely by Dr. Lodge's experiments we might easily conclude that an ordinary solid lightning rod would afford but very little protection, or at least that it would not shield a building from side flashes which, if not very destructive, would be most alarming to the inmates. Now this is not in agreement with experience. In this country we have but little opportunity of finding out to what extent our conductors fulfill their supposed functions, for storms are not frequent and are never severe. But on the western plains of America, where atmospheric disturbances are on a much grander scale than here, the lightning rod has established itself as absolutely essential. It is applied to every building—houses, barns, and stables—so that a homestead literally bristles with points. In a country where the level plain stretches mile after mile without a hillock or a coppice, every prominent object becomes a discharging point through which electricity streams each time a thunder cloud drifts across the district. At night the ridge of an unprotected house may be seen aglow with the blue electric brush, while if it be provided with conductors, their points will absolutely flame with discharge. Often the electrified particles of air will furnish a path along which a flash will descend from the clouds. In such case there is no doubt where it strikes. The air of the house is filled with the powerful odor of ozone, and the flesh of the inmates creeps from the induced current which passes over the skin simultaneously with the discharge from the sky. But, in the great majority of cases, no harm is wrought. The electricity gets safely to ground through the conductor in spite of the self-induction of the rod.

Rods of different shapes and metals are employed, and practice has failed to award the palm to any particular form or material. Cylindrical and flat rods, both of iron and of copper, have been found efficient when properly erected, and, on the other hand, both shapes and metals have failed when not suitably fixed. Dr. Lodge believes that an iron conductor is better than a copper one, founding his opinion on experimental evidence deduced from the length of spark which can be obtained in an air shunt circuit forming a by-pass to a metallic circuit traversed by an electric discharge, figure 1. He argues that the greater the resistance offered by the metallic conductor L, the greater will be the air gap which the spark will leap to relieve itself by another path, B. The figures obtained were 1.43 in. for stout copper wire, and 1.08 in. for similar iron wire, showing apparently that the iron wire opposed the least resistance to the discharge. That may be so, but we would point out that the attempt to measure sparking distances to the hundredth of an inch is unsatisfactory unless done with precautions which are not mentioned by Dr. Lodge. If an

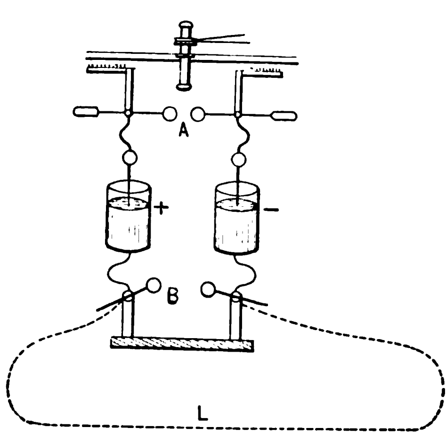


Fig. 1.

air resistance is to be made the standard of measurement the air must be absolutely free from dust, and each spark must be taken through a body of air not previously submitted to the discharge. The need of these precautions must be self-evident to all who have experimented with statical electricity. No two successive sparks in the open air follow the same path; they appear to leap from dust particle to dust particle, seeking for stepping-stones to bridge the gap. Again, the sparking distance between two terminals rapidly increases after the first two or three discharges, and when a path has been formed through the air, the gap may be increased very considerably. In the face of these facts, sparking distances measured in hundredths of an inch in the open atmosphere have but little quantitative value, unless they can be reproduced time after time with certainty. Dr. Lodge does not tell us upon how many experiments he bases his opinion that iron rods are better conductors of discharges than copper ones.

The fortuitous character of the electric discharge is well exemplified by the following experiments, which have been made by Mr. James Wimshurst, at our suggestion. As is well known, Mr. Wimshurst's laboratory is equipped with influence machines of a size and capacity transcending all others, and from which sparks up to 15 in. in length, and of enormous quantity, can be obtained. He has, therefore, the means at command to carry on experimental investigations in the region of atmospheric electricity on the largest scale, added to an experience of many years in which the successful production of electrical phenomena has been a constant

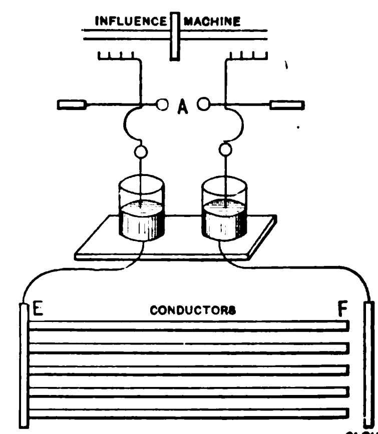


Fig. 2.

study. All this valuable apparatus, and his more valuable assistance, Mr. Wimshurst is always ready to put at the disposal of scientific workers, and our thanks are due to him for the aid he has furnished us in the following investigation into the comparative security offered by different kinds of lightning rods. The experiment, or rather the series of experiments, had for their object in the first place to determine to what extent an electric discharge would exercise a selective action if a number of paths were presented to it. It was certain that it would display some preference, for if a wooden rod and a copper rod be placed side by side, lightning will follow the metal path and not the wooden one. But will it select a copper rod in preference to an iron one, or a flat rod in preference to a round?

The arrangements adopted followed those of Dr. Lodge up to a certain point. In both cases it was the sudden or impulsive form of discharge that was used. This was for two reasons; first, because it is believed that this kind of flash is far more dangerous to buildings than that which has a path prepared for it by induction; and second, because it is practically impossible to get an induction spark to leap into a rod unless it be capped with a ball, which is a most serious departure from the conditions of actual practice and vitiates the conclusions which may be drawn. The impulsive flash occurs during a thunder storm, when a cloud high in the air suddenly discharges into a lower one, and this again discharges to earth. In such a case the electricity strikes for the nearest conductor. But if a charged cloud stands over a building for some time before striking then it draws electricity from the earth, and this produces currents of electrified particles of air from all the points of the roof towards the cloud. If the building be provided with a conductor the charge in the cloud may be actually neutralized in this way, or there may be an upward flash from the rod. In any case the probability of the discharge being confined to the rod is far greater than with an impulsive flash. In the laboratory a brush is seen on the point of the rod, and the electricity leaks away faster than any machine can supply it.

Figure 2, shows the arrangement adopted by Mr. Wimshurst, in the first series of experiments. The terminals of the influence machine were connected respectively to the insides of two groups of Leyden jars, each group consisting of one two-gallon jar and three one-gallon jars. The outsides of these sets of jars were connected respectively to two plates, E, F, between which the rods were arranged, one plate representing the earth and the other a cloud. The rods were laid horizontally upon glass supports, and were separated from the imitation cloud at one end by distances commencing at 1 in., and gradually increased inch by inch up to 5 in. At each stage 20 successive sparks were discharged from the cloud towards the conductor, and it was noted which rod was selected. The following rods were employed:—

1. 5 ft. of No. 14 B. W. G. copper wire.
2. 5 ft. " " iron wire.
3. 5 ft. of copper riband of equal section to No. 1 copper rod, ⅜ in. wide.

1. *Engineering* (London).

4. 5 ft. iron riband equal in section to No. 1 copper rod, ⅜ in. wide.
5. 5 ft. of No. 14 B. W. G. iron wire inclosed in a thin copper tube.

When the distance from the cloud to the rods was 3 in., and their other ends were placed to earth, the following results were got:—

The copper rod was selected 6 times.
" iron " " " 5 "
" copper strip " " 5 "
" iron " " " 3 "
" copper covered iron was selected 2 times.

The distance between the ends of the rods and the cloud was then increased to 4 in., and the following results obtained:—

The copper rod was selected 4 times.
" iron " " 2 "
" copper strip " 13 "
" iron " " 3 "
" copper covered rod was selected 2 times.

With a 5 in. distance the results were:—

The copper rod was selected 13 times.
" iron " " 5 "
" copper strip " 0 "
" iron " " 2 "
" copper covered rod was selected 2 times.

It would be unwarranted, we think, to draw any conclusions from these experiments except that the course of the discharge is determined mainly by atmospheric conditions, and that a metallic conductor, if it be of sufficient size to carry the current without destruction, may be of iron or copper, and round or flat, as may be most convenient. If we attempt to reckon up the totals of the three experiments we find that the copper rod shows the best score and the copper strip the next best, but a comparison of the behavior of the copper strip in the second and third experiments shows that this method of estimation is very risky.

Four other experiments were made with bad earths, that is, there was an air gap at the foot of the rods, as well as one between the rods and the clouds. The former was made successively ¾ in., 1 in., 1½ in., and 2½ in. Eighty-one sparks were passed and an account kept of the rods struck. The following are the aggregate results of the four experiments:—

The copper rod was selected 11 times.
" iron " " 20 "
" copper strip " 20 "
" iron " " 13 "
" copper covered iron 17 "

If we attempt to draw any conclusion, it is that an iron rod and a copper strip stand on an equality. But an examination of the detailed results, which are too long to give here, shows that the selection was very erratic. One rod would be struck several times in succession, and then would be entirely neglected for a time, and we are forced to the conclusion that atmospheric conditions had a great deal to do with the path chosen by the spark. When the issue was narrowed by using only two rods at a time rather more definite results were obtained, and the spark exhibited some preference for the round rod over the strip. But it was apparently the form rather than the metal which influenced the selection.

When witnessing these experiments the conclusion which presented itself to the mind was that a good conductor might be made either of iron or copper, and be flat or round as was most convenient for structural purposes. If a perfectly uninterrupted metallic path of a size which will not suffer from the heating or deflagrating effect of the current be offered to a discharge, the electricity may be relied upon to follow it. But it is most important that it shall be uninterrupted, and this condition is difficult of attainment with a lightning conductor. The earth contact forms a break which needs to be very carefully bridged to render it as efficient as the remainder of the circuit, and if it be not thus bridged fine-drawn distinctions between different sections of rods become mere waste of words. For instance, if the iron and copper rods mentioned above be laid side by side, and one be connected metallically to the earth plate while the other is kept ¼ in. away and the gap bridged by a piece of thick brown paper soaked in water, the spark will select the metallic circuit every time. It does not matter whether the copper or the iron be the metal with the bad earth; it is always shunned and the other rod is followed. Mr. Wimshurst has made some experiments with earth plates, which are most instructive, as showing the very ample surfaces which they require to have. A model house was taken with a flat metal roof 8 in. square. The house was divided by floors into three stories, and in the upper room there were metallic brackets, representing gas and water fittings, projecting from the walls. Down the side of the house ran a copper lightning rod which could be put to earth in various ways. The gas and water pipes were also connected to earth. Over the house stood a copper plate representing a cloud. This plate was connected to the outer coating of one Leyden jar, while the outer coating of the other jar (figure 2) represented earth. In the first instance the conductor was connected metallically to earth and successive sparks were passed into it from the cloud. There was then no sparking between the metallic roof and the gas and water fittings, either when the roof was connected to the conductor or when it was not. Apparently all was safe, although, as we shall show later on, the plan of connecting metal roofs to the lightning conductor is not without danger. An artificial earth was then interposed between the bottom of the conductor and the Leyden jar, by aid of a porcelain dish partly filled with damp garden mold. A layer of earth about 1 in. thick was first placed in the dish, and on this were laid two metal plates, each measuring 7½ in. by 3¾ in. The adjacent long edges of the plates were separated by 2½ in. Over the whole another layer of earth, 1 in. thick, was laid, and the entire mass firmly consolidated by pressure. One plate was connected to the lightning conductor and the other to the outside of the Leyden jar, the discharge having to pass through the mold between the edges of the plates. The degree of humidity of the mold was in excess of that ordinarily existing in garden ground at a depth of 4 feet or 5 feet. The influence machine was then worked and sparks passed from the cloud to the conductor in rapid succession. In every case a part of the discharge leaped from the roof across 1½ in. of air to the gas bracket and got to earth that way. When the roof was connected to the lightning rod the current had no difficulty, of course, in reaching the gas fittings. But when this connection was broken, the spark had first to leap from the rod to the roof and then from the roof to the gas pipe before it could find the easy path it required.

These experiments put in the strongest possible light the need of having a very large surface at the earth plate of a lightning rod. Twenty-eight square inches were provided for the escape of a spark which must have been infinitesimal compared with a flash of lightning, and yet they were utterly insufficient for the purpose. The discharge was ready to dart out of the rod wherever an easier path was to be found. If it had been a real flash it would have displaced the coping or rent the wall in its path to the metal roof. The damage did not occur at the earth plate. A little disturbance there might be viewed with unconcern, but it is quite another affair to have a flash of lightning hunting round the inside of a house to find a road leading to earth. Yet if an impulsive flash enter a rod this result will certainly happen if the ground contact be insufficient. Most people who have dabbled in electricity have unexpectedly proved this on their persons in attempting to discharge a Leyden jar. If one end of the usual discharging tongs (without the glass handle) be applied to the outside of the jar, and then the other end to the knob, no effect is felt by the operator. But if, in manipulating the upper arm, he inadvertently allows the lower arm to leave the surface of the jar by a fraction of an inch, then he gets a share of the contents of the jar, which teaches him a lesson of caution he never forgets. He is just in the position of a man standing beside a lightning conductor with a poor earth contact.

In towns the underground pipes lie very temptingly to hand for connection to conductors, and we do not see why they should not be used. The water pipes are no doubt better for the purpose than gas pipes, as there is generally sufficient leakage from them to insure a good deal of damp earth in their vicinity. But any pipes which are jointed metal to metal may be used with impunity. It may be that the electricity will have to travel a considerable distance before it all escapes, but there is no fear of its entering the neighboring houses. The electrostatic capacity of a system of mains is so great that it is impossible for it to be charged to a dangerous potential by a single flash, even supposing there were no leakage. In a previous article we referred to the fact that the immense lead roof of the dome of St. Paul's was insulated at one time, and yet held all the flashes it must have received without harm, and it is certain that long lengths of pipes would act in a similar way. Of course they must be metallically connected with each other; joints of india-rubber or white lead would interpose very considerable resistance to the current. Failing pipes, an earth plate must be used. It cannot be too large, and it must be placed in ground which is damp in the dryest summer.

It is an established practice to connect all metallic roofs to lightning conductors, and Dr. Lodge recommends it. Since the date of his lecture, however, there has been a notable example of a building on the continent, in which the roofs were so joined, being struck by lightning and set on fire. Now Mr. Wimshurst's experiments, detailed above, have shown that when there is a bad "earth" to the conductor the lead roof serves to convey the current to all parts of the building, so that a person standing in the upper story runs the greatest possible risk of being struck, particularly if his body offers a convenient path to a water or a gas pipe. This is more particularly true if the lightning rod be connected to the roof. If it be not connected then there is the possibility that the discharge may find an escape without entering the roof at all. In one experiment the earth contact was represented by a break in the conductor, ⅝ in. long, filled with a tube of wet paper tightly rolled round the two separated ends. When an impulsive flash leapt from the cloud there were always sparks inside the house, a part of the current escaping by the imitation gas pipes every time. When the earth contact was good there were no sparks, but there is reason to think that the upper floor of the house was

even then a dangerous locality, as will be seen from another experiment.

When a thunder cloud stands over a district it attracts a charge of opposite name in the earth and buildings beneath it, and when the cloud discharges itself this induction charge is set free. Now it is argued in the case of a lead covered house that this charge may spark off and do some damage, and therefore a path should be provided for it by connecting the metal to the lightning rod. Further, Dr. Lodge considers that a lead roof may play a very useful part from its electrostatic capacity. He likens it to an air vessel or a pump, and suggests that it receives and stores a part of the flash and then gradually emits it, thus reducing the rush in the conductor, and preventing the pressure in it becoming so great that sparks will flash off from intermediate parts of the rod. If we endeavor to verify this experimentally by connecting the cloud over the model house to the inside of a Leyden jar, while the foot of the conductor (which must terminate in a knob) is connected to the outside, then we find that by presenting a knuckle to the roof we can draw a spark every time the cloud discharges. This happens whether the roof be connected to the conductors or not, but the spark is the sharper when the two are joined. If, however, under the latter condition one finger be placed on a gas bracket while another is presented to the roof, a comparatively severe shock is felt. Under the conditions of an actual storm this shock might be very serious. For instance, a man washing his hands in a fixed basin, with a metal waste pipe would be in a perilous position if under a lead roof connected to a lightning conductor. Again, a house with composition gas pipes would be very likely to be set on fire if a flash struck into them, for the metal would melt and the gas be ignited. The danger can be minimized by connecting the roof to the ground by its own conductor, quite independently of the lightning rod. When this is done in the model house no shock is felt, even when the hand is interposed between the roof and the gas bracket. As a matter of fact, it would be difficult to find an instance of an insulated roof, for the down spouts generally are in metallic connection between the covering and the ground. Of course, they cannot be relied upon to make good "earth," but if the roof be only protected from a flash entering it, either directly or from the lightning rod, any charge it may get inductively will not greatly matter.

The outcome of these experiments is to restore our confidence in the ordinary lightning conductor, which had been a good deal shaken by Dr. Lodge. They show that the causes of failure are to be sought rather at the ends of the rod than in the conductor itself. At the bottom it is most essential that a perfect earth contact should be secured; without this a lightning conductor is a gratuitous source of danger. At the top there must be a point at each stack of chimneys or other projection, for it is not safe to rely upon a large area of protection from a single terminal. Metal roofs should be kept away from contact with the lightning rod, and so should gas and water pipes. If not they provide an open road for the distribution of lightning within a house. At the same time, additional security is gained by providing all large masses of metal with independent conductors so situated that they cannot easily become paths for electricity from the clouds. Thus, if by any chance the current should overflow from the main conductor, it will soon find a ready path, and will be prevented from darting backwards and forwards, trying first one piece of metal and then another. If these precautions be observed there should be little danger from lightning, whether the conductor be round or flat, or be of iron or copper.

ELECTRIC LIGHTING IN AMERICA.[1]

BY PROFESSOR GEORGE FORBES, F.R.S.

Having since the last meeting of the British Association had occasion to pay two visits to the United States, and while there to study very carefully the systems of central station lighting in vogue, and also to compare what was being done there with what was being done here, and being, further, able to compare the state of central station lighting in America as it is at present with the condition it was in four years ago, when this association visited America, I felt it was a sort of duty I owed to the association to bring before it some account of what I had seen, believing it would be especially interesting at the present moment, when there are signs of a very great determination on the part of the public in this country to have electric light supplied to them from central stations. At the same time I felt considerable diffidence in bringing before you the facts which have been collected—not in the least because there is any want of facts, but by reason of their number, which renders it difficult to make a proper selection of the points likely to be of interest to the members of this section.

In the first place, it has been often stated, and one cannot help commencing remarks of this kind by repeating, that enormous progress has been made in central station lighting in America. At the moment one lands, one is struck by it; and when one lands, upon returning to England, one is equally struck by the dimness of the lighting in our streets. In America, there is not a single town with which I am acquainted where you can walk in the streets at night without seeing very many arc lamps. I am not simply speaking of influential towns like New York, Philadelphia, and Boston, but of the most out-of-the-way places in the most distant states, where gas has never penetrated. There electric lighting has fixed its position, and it is being used frequently. Not only has the electric light been adopted in these remote towns, but other developments of electricity have followed. As an illustration of the kind of places to which electricity and electric light have found their way, I may mention that I have a paper here published in a village in Alaska, one of the least developed of the territories of the United States, and the same number of this paper, which treats of the introduction of electricity in a scientific manner, treats also of the advisability of passing a law for the expulsion of Indians from the city at nine o'clock every evening.

At the time I was attending the Electric Light Convention at Pittsburgh last February, it was estimated that there were then 300,000 arc lamps lighted from central stations in America. The progress of arc lighting of late years, however, has not been so striking to an Englishman as formerly; the arc light was firmly established when the British Association visited America four years ago. The progress which has struck us all latterly has been the progress in incandescent lighting. At the same time—I am speaking of February of the present year—it was estimated that there were 2¼ millions of incandescent lamps in use in the United States; and the rate of manufacture has increased enormously, to my knowledge, since that short time ago There are four or five manufacturing places in the United States at this moment, each capable of turning out 10,000 incandescent lamps every day, and I have no doubt that the annual production at this moment is to be counted by millions. Of incandescent central stations, there are two classes, one of which is the three-wire system, in which a continuous current is supplied to the main conductors over a town, and the lamps are connected by branches to the system of positive, negative, and intermediate mains. That is the system which is so largely adopted in all the Edison stations; it was the Edison stations which interested us most in 1884, and they have continued to advance and have developed the three-wire system to a very great extent indeed.

But I feel quite sure that the greatest progress that has been made in central station lighting in America since the association visited it has been by the work which Mr. Westinghouse has done in that country. One of Mr. Westinghouse's agents in passing through Europe saw the experiments, which had been made by Messrs. Gaulard and Gibbs in this country in the use of alternating currents to distribute the electric light; by means of this system an alternating current of very high tension could be passed along the streets over conductors of very thin diameter and very cheap to construct, and at the consumer's premises this high tension dangerous current could be reduced in tension by means of an induction apparatus called a converter and passed into the house at a harmless pressure suitable for the ordinary incandescent lamps.

And here I may say that I never fail to take any opportunity which presents itself to me to say what I feel with regard to the energy and determination with which Messrs. Gaulard and Gibbs, in spite of the most adverse criticism which was universally passed upon their first attempts, persevered and continued to improve their invention and eventually proved to the world that it was possible to have a commercial system by means of these converters.

Mr. Westinghouse, on seeing this system, took it up, and the result is that he has established, in the course of a very few years, an enormous business in central station work. It is now a possibility in America—not a possibility merely, but a thing of daily occurrence—for a town to write an order for a central station, which has to be sent out at ten days' notice. They do not order a dynamo, set of conductors, and other apparatus all independently, but complete central stations are being sent out at a steady and uniform rate. In December of last year the manufacturers of incandescent lamps drew out a long list of the number of lamps being used in different parts of the country, and I have abstracted from that list some notes which show that at that time Mr. Westinghouse's alternating current system was supplying 153,285 lamps, occupying 152 distinct plants, and 42 of these had plant for more than 1,000 lamps. At the present moment they have set up 110 central stations with 191,000 lamps.

It has been said that in this country we do not go ahead so much as they do in America, and various reasons have been suggested to account for this. Professor Ayrton's most admirable reason seems to go a long way—namely that there are two definitions of inertia, the English, which is that inertia is a resistance to motion, and the American, that it is a resistance to stopping. But I must say that in electric lighting we certainly have been stopped a great deal by what I might almost call the iniquitous Electric Lighting Act. And I regret extremely, in

1. Read before the British Association for the Advancement of Science. September 10, 1888.

the interests of the public and of electric lighting generally, that an act has been passed this year which has not yet put electricity on the same footing as gas. This is a matter for extreme regret to all those who have the ultimate benefit of the electric lighting industry at heart, for that Act will delay the due recognition of the value of electric lighting.

But I must say that I do not think the Electric Lighting Act is the only thing which has delayed our progress, because I see that in electric traction and other developments of electricity also the Americans have gone ahead with great energy, and I certainly do not put it down to want of capacity on the part of our inventors, for I find that the best dynamo machines are all designed originally in England, and the best arc lamps there are are to be found in England; but with inferior machines and lamps in the states, I have noticed that they are determined, as long as they have something which they know will work well, to make it work, and be ready in the meanwhile to take up something else. I think, therefore, that it is not in the inventors that we have to look for goaheadedness, but to men of capital who are technically instructed. I think it is technical instruction among the moneyed classes that has developed electrical engineering so much in America of late years.

I will now try to describe some of the leading features of the Westinghouse central stations which I visited, and perhaps this may be of use in helping us to draw some conclusions as to the lines in which we are to develop electric lighting in our own country. I do not in the least wish to say that the American arrangements are the best. In many points I see objections, and many where I should wish to see improvements; but we have in the system which I am going to describe a thoroughly successful working arrangement, and although we in this country may not adopt all the points of such an arrangement, still I feel that it will be of use to us to realize what is being done on the other side. It is a curious thing, for example, that in America there is no work hardly being done with accumulators. There is an example where we have led the way, as compared with the Americans. I was struck with the fact in 1884, and still more in the present year, that accumulators do not seem to work in the American atmosphere; at any rate, people have been importing numbers of accumulators, and yet they are not recognized as the satisfactory apparatus we have come to regard them as; they are looked upon there as being as uncertain now as they were with us four or five years ago.

The Westinghouse system, then, chiefly depends upon the apparatus which has been called by the names secondary generator, transformer, or converter; "converter" is the term generally adopted in America. This is simply an induction apparatus with two coils, a primary and a secondary. The primary coil, in contra-distinction to the ordinary Rhumkorff induction coil that we have known so long, is of high resistance, with a large number of turns on the primary and a small number on the secondary which goes to the lamps. The alternating current produces induction in passing through the primary, which reacts on the secondary, thereby producing a current of low tension going into the houses. The primary coil and the secondary are completely separated, and when properly constructed, it is quite impossible that the high tension current can ever reach the secondary circuit, so that the consumers of electricity have nothing to fear from the dangerous current which is distributed from the central station.

A central station contains furnaces and boilers, engines, alternate current dynamos, exciting dynamos, switch-boards, testing instruments, repairing shop and stores. The scheme of arrangement of the mechanical and electrical parts is generally the same in every station.

The wires led out from the station are carried generally on poles as feeders to the separate districts. The converters are generally attached to the outside wall of the house to be supplied; but they are often attached to the poles carrying the feeders. They are sometimes placed inside the houses. The secondary wires inside the house, to which the lamps are attached, are laid in the usual manner, and are connected to the secondary poles of the converter. The dynamos are run day and night without cessation. Charges are made by contract or by meter.

We hear a good deal here of the impossibility of running machinery day and night without breakdowns, and I cannot help rather endorsing the opinion I heard universally expressed in America—that this fear has been enormously exaggerated in this country. When we see our huge 10,000 to 15,000 h. p. engines crossing the ocean, performing their work for days and weeks without breakdown of any sort, it seems absurd to expect that where we are able to subdivide our power, as in a central station, there should be any serious breakdown in a properly organized system. As a matter of fact I assure you that in America plants which have been run without accumulators have been going on for years and years, and it is a matter of the utmost rarity for an accident to arise of sufficient importance to stop the general lighting of the district. The Edison central station in Pearl street, New York, which has been running many years, has, I believe, only once broken down, and that was an accidental occurrence due to too much current being turned on on a foggy day, and the experience of other central stations is to the same effect. The general view in America is that there is no danger of a breakdown ever happening in a properly organized station.

It happens that in the department of furnaces and boilers there is much of special interest in many of the Westinghouse stations. This arises from the fact that over a great part of Western Pennsylvania the fuel employed is the natural gas obtained from the wells in that region, and carried in pipes to considerable distances. But this is a feature so peculiar to the district that it requires only a short notice here.

The gas, with its due proportion of air to produce the high temperature of a Bunsen burner, is admitted by pipes with a sufficient number of nozzles into the combustion chamber. Here the burning gas passes over a mass of bricks with ventilating spaces, and thence through the tubes of the boilers. The gas is nearly free from carbon, and the hydrogen, which is paramount, undoubtedly weakens the iron of the boilers; but practice shows that this action does not go far, and the iron acquires a final condition in which it does not deteriorate, but seems capable of indefinite use.

In the best stations the admission of gas and air to the furnaces is regulated by means of a valve controlled by a lever, which in its turn is subject to the pressure of the steam in the boiler. This automatic regulation is very perfect, so that the attendance of one man to the boilers and furnaces of a station with several thousand horse-power is quite sufficient.

As to steam engines there is no need to say much, for I do not think the Americans can teach us anything about making steam engines. But there are some points in connection with the class of steam engine used which I think are of importance. A great deal has been said about the desirability of having central stations furnished with large, powerful, slow-running engines which are economical in the consumption of coal. Practical experience, however, has decided the question for the present exactly in the opposite manner. It is found to be more economical and safer to have a number of dynamos in each station, each driven by a separate engine of high speed, the power being transmitted through a belt and with no countershafting. About the rights of this question there cannot be the slightest doubt. It has been proved over and over again by experience. At first sight it does not seem probable that a number of independent high-speed engines should be more economical or safer than a single large engine, say of the marine type. The explanation lies in the special conditions of central station lighting. Without dwelling upon the great loss of power due to countershafting with the large engine, it is only necessary to observe that the maximum load in a lighting station is many times as great as the average load. Thus, if the single engine be adopted for the maximum load, it is working underloaded during the greater part of the 24 hours. The consumption of steam in proportion to power developed is very high, and the engine is under these circumstances not an economical one. With the independent engines, on the other hand, none of them need at any time be working much under its best load, and when the load increases other engines and dynamos can be switched in, and they are thus always working at or near the most economical conditions.

It has been found from actual practice in electric light work in identical central stations that 20 per cent more work is required in the case when countershafting is introduced.

It has also been proved from the experience of numerous central stations, that during a considerable number of hours in the night the load on the engines and dynamos is only one-eighth part of the maximum load.

For these reasons it is found most economical to use with each dynamo an engine whose most economical load is something like 20 per cent under the maximum load. Waste of steam is far greater with underloading than with overloading.

Another advantage of this system is that there is abundance of time for the inspection of engines and dynamos. The station is easily added to. A breakdown in an engine or dynamo does not stop the working of the station. There is one other factor of safety to which attention must be drawn. One of the most annoying accidents in an electric lighting plant is that due to a short circuit on the mains. In overhead work this often happens by the falling of broken telephone or dead wires upon the mains. In this case a small independent engine is pulled up and no damage is done. With the large engine the dynamo grinds on, and unless the cause of short circuit is burnt up, the dynamo is destroyed, or at any rate the whole of the working is put out of gear.

Now I have a word or two to say about dynamos and converters, the actual apparatus which are used in America. I attribute a great deal of the manufacturing success of American electric lighting plant to this, that they fix upon the types of machine that they are going to make, and then lay down machinery which will enable them to produce those types cheaply, and having thought out the system thoroughly in the beginning, they do not require to make a completely new type of machine for every order that comes in. They are then able to manufacture their machinery cheaply, and in such a way that every part is replaceable.

At this moment I think if I had to choose between two dynamos of which one was a little better than the other in efficiency, but the other of which was manufactured in this way, I should be very much inclined to lean in favor of the one which was made by machinery, and of which all the parts were interchangeable, and of which I could get any one of the parts by return train by telegraphing for it. The convenience of such a machine is obviously great.

I have, for the benefit of those who are electrical engineers and manufacturers, thought it might be of interest to put down some facts in connection with the three types of alternating current dynamo machines made by the Westinghouse company. There are three types, one for 650 lights, another for 1,300, and another for 2,600. The voltage of all is the same, 1,050. In this country there has been a tendency to use on the primary circuit a higher tension than that, 2,000 volts. In the Westinghouse system they use 1,000 volts at the converters, and 1,050 is developed by the machines. The local pressure is reduced in the same proportion as has been done most generally in Europe, that is to say, in the ratio of 20 to 1. The 1,000 volts in America is reduced down to 50 volts in the lamps, and in this country the 2,000 volts has been reduced to 100 volts at the lamps. And here there is a question opened which must be decided immediately in the central stations which are going to be put down in this country, whether you are going to take the full advantage, as Mr. Westinghouse does of being able to carry your high tension current in the mains.

The advantage is that you are able to save copper to a very great extent indeed, whether you use 1,000 or 2,000 volts, and then, as Mr. Westinghouse argues, we are able to use lamps of only 50 volts instead of lamps of 100 volts; that he looks upon as the greatest advantage he has gained by the introduction of the Gaulard and Gibbs system. We all know that the higher the voltage of the lamp the shorter its life, and a 50 volt lamp is a far more perfect thing than a 100 volt lamp. We are greatly troubled by the expense of lamps compared with their life. That is an expensive item in the supply of electricity, and, a 50 volt lamp being far more economical, is it not desirable to follow the American plan and use the lower voltage? I am sure that electrical engineers generally will see that there is a point worthy of their serious consideration in this question.

It may even be said that we are all to go still further and reduce the voltage a great deal more. Of that I am less certain; but there is another point which will occur to electrical engineers, whether it is not desirable to use the lamps which Mr. Bernstein has been perfecting, of very low voltage, placed in series. At present one of the most serious difficulties in introducing electric light for domestic purposes from central stations, is in the cost of wiring houses. Now, if we place our electric lamps all in series, the cost of wiring will be very much diminished, and it becomes a question whether this is not the best arrangement. In that case the primary coils of our converters would be put in series in the same way as they were originally in the Gaulard and Gibbs system. We shall then be doing what they were striving to do when they chose the series arrangement, namely, not by having the two primary terminals inside the house at a difference of potential at 1,000 or 2,000 volts, which would be dangerous, but no two conductors of greater difference of potential than about 50 or 100 volts. If at the same time we use low voltage lamps, we shall get a longer life than even Mr. Westinghouse has obtained. It seems to me that there are grave reasons for considering most seriously the question of arranging all our lamps in series and the primary coils in our converters in series also.

But I am not here to put forward suggestions about what we may probably do in England, but only to tell you what they are doing in America, wishing at the same time to guard myself from saying that they have the best arrangements in every possible point.

The construction of the Westinghouse dynamo is pretty well known in this country, and it is needless to speak of it.

I think we are probably all agreed that the old type of alternating current dynamo, such as the Siemens, has probably seen the end of its days. One of the chief difficulties seems to be that when you have such a large number of coils revolving between the poles you are obliged to make a considerable clearance, and that causes you to use up a great deal of power in magnetizing the field magnets. Mr. Westinghouse makes a very small clearance and in that way uses up only 2 % of the maximum power.

The Westinghouse company makes those types of dynamo, of which the following particulars are of interest:—

Dynamo No.	i.	ii.	iii.
E. M. F.	1050	1050	1050
Current	35	65	130
Resistance (armature) at 30° C.	.76	.37	.15
" (fields) " " "	14.5	7.0	3.6
Weight of wire in armature	17	30	60
" " fields	420	..	..
Total weight	4800	9000	..
No. of lights	650	1300	2600

The No. iii, has an armature about two feet diameter and two feet long. It has 16 poles, and runs at 1,000 revolutions per minute. The armature plates have each six large holes for ventilation and lightness. The weight of armature is 2,000 pounds. The insulation is mica and copal varnish, which is found to be infinitely superior to shellac or any other material tried.

The converters used by the Westinghouse company are of five sizes, called by the numbers i., ii., iv., vi. and viii. The following table gives particulars about them. The size of wire is on the B. and S. gauge:—

Converter.	i.	ii.	iv.	vi.	viii.
No. of lights	5	10	20	30	40
Wire on primary	25	22	19	17	16
" " secondary	11	8	8	8	7
Turns on primary	900	700	560	480	400
" " secondary	45	35	28	24	20
Resistance of primary	48	21.9	9.9	7	5
" " secondary	.04	.043	.0197	.0176	.0107
Weight finished (lbs.)	50	60	95	..	160

Thickness of iron plates — .006 to .0065 inch.
" " paper insulation — .0025.
Number of plates in a No. 8 converter — 1350.
The iron used is Welsh Taggard iron.
50° C. rise in temperature is allowed in the converters.

In this country the tendency is to make converters much larger; it has even been suggested that they should be made of thousands of lights. But for ordinary use in houses the Westinghouse system is the simplest, more especially as we find that it is necessary to wire the houses in such a way that they will suit our meters, which at present do not go over a range of from one lamp up to a thousand lamps, nor even up to hundreds of lamps, and if we find that our range is suitable up to 40 lamps it is very desirable to wire the houses in such a way that there are not more than 40 in the circuit of a meter indicating 40. For this reason Mr. Westinghouse has limited his converters in this way.

There are some points well worthy of attention in regard to converters. In the first place, by the use of only 1,000 volts, a far cheaper converter may be made, and thus a great saving may be effected in the plant required for a house. Then, again, there is the rapidity of alternation. In the Westinghouse plant there are 16,000 alternations, 8,000 complete periods, per minute. In this country the tendency is to make the alternations less than that. The quantity of iron you put in your converters depends on the number of alternations; the greater the number of alternations the less iron is required, and you are therefore able to use smaller converters. I do not know whether or not there are objections upon other grounds to a high number of alternations. The only objection that occurs to me is that, while the construction of the dynamo sometimes becomes a little easier, it also takes a little more space.

Mr. Westinghouse asked me to make some tests for him on the efficiency of his converters. It has been supposed that converters have not a high efficiency when working at half load. I may mention that the efficiency varied slightly in the different types, owing to the proportions of iron being greater in some types than in others; but at half load in some cases we were able to get an efficiency of 95 per cent,, which is a splendid result, and I think a greater efficiency than most people have been supposing was to be attained. I do not think that in actual practice there is an average waste of 10 per cent. in the use of converters, when they are properly designed. The formulæ which regulate the construction of converters has been given by me in the *Journal* of the Society of Telegraph Engineers and Electricians, February, 1888.

I may also say that Mr. Westinghouse has in his lamps 70 per cent. of the power given to the belt by his engine, which is a very good return for converters and alternating dynamos, showing that the new alternating current machines are much superior to the old one, which gave about 70 per cent. efficiency.

The wiring is nearly all overhead in the states. The wire used is called simplex wire, and is made by a firm in Boston. It is very carefully prepared, and is, I think, beginning to be known in this country, and gives satisfaction.

For underground work Waring cable, which is lead-covered, is used with complete success. I am informing you now of what is being used, and used successfully, and what may be used successfully by us in this country; but you must not suppose that I hold that these arrangements are the best.

Now comes a most important point of distribution. Ought the conductors to be massed in one heavy main, with all the dynamos feeding it, or ought the main to be much subdivided, with, perhaps, several to each dynamo? or ought we to take an intermediate arrangement? The experience of the Westinghouse

company leads to the subdivision of mains as far as possible, because a short circuit on any main then endangers only one dynamo.

I have often been asked the question whether alternating dynamos can be worked in parallel. They can, when they are fully loaded down almost to half load, but below that they do not synchronize. Great subdivision of the mains has been found in practice to facilitate largely the working of the central station.

There is one thing that will probably be spoken about in the discussion which will follow my remarks, and that is the high speed of the Westinghouse dynamo. I think there is needless objection to high speed by engineers in this country. If we have a uniform cylinder of iron revolving, I have no objection to any rate of speed so long as I know the shafting will not give way.

I think it would be desirable that some of the gentlemen present should give us their views as to the desirability of using a high or low number of alternations, high or low voltage in the primary, whether 50 volts will be desirable in use, and also as to whether subdivision of mains is desirable, and whether the converters should be supplied have only a limited number of lamps, such as 40 or 50.

I have now attempted to give you a general idea of working central stations in America on the system which has been most fully developed of late years. It is the result of a great amount of careful work, and in the work of the immediate future in England I am sure that English engineers will be benefited by the large practical experience which our trans-Atlantic cousins have collected.

SKETCH OF THE ELECTRICAL PAPERS IN SECTION A, AT THE RECENT BATH MEETING OF THE BRITISH ASSOCIATION.[1]

BY PROFESSOR OLIVER J. LODGE, F. R. S.

Some talk of Isaac Newton, of Euler and Clairaut
Of Kepler and Copernicus, and old Galileo;
But of all the mathematicians
There's none who can compare
With the row dow dow de dow dow dow
Of the British Engineer.

THE above verse may be said to strike the keynote of the recent British Association meeting at Bath, as it appeals to an outsider. The note was struck both in the presidential address and in the address of the president of section G, and it has been further emphasized, no doubt beyond the meaning of either president, by an instructive leading article in the oldest engineering journal. The following extract is from the *Engineer*, of date September 7:—

"Sir Frederick Bramwell's address is mainly a pleasant discourse on the part which the engineer has played in the world, and is principally remarkable as a well-constructed refutation of the preposterous pretentions put forward by some men of so-called pure science. * * * The theme is so congenial that we feel no keen desire to criticise what Sir Frederick Bramwell had to say. Our only quarrel with him, indeed, is that he did not go far enough, or press his arguments with sufficient insistance. Possibly it was impossible or impolitic to push his arguments home. * * * No one, however, knows better than Sir Frederick that the world owes next to nothing to the man of pure science. In another page we give an abstract of the address, from which it will be seen how carefully Sir Frederick avoided the utterance of a word that might give offense. But we are not tied or bound by any consideration of this kind, and we should be lacking in our duty did we not assert whenever the occasion for assertion arises, that the engineer, and the engineer alone, is the great civilizer. The man of science follows in his train."

Meanwhile, in the quiet and peaceful atmosphere of section A, some good work has been done, and in the calm temperament engendered by such work and by the assured feeling of progress in insight and knowledge, there is a disposition, I doubt not, to grant to the engineer all the credit he, or others for him, can possibly claim, and not to resent even such a singular tone as is sounded in the above quoted leading article. There is, after all, some excuse for a good deal of self-glorification when the society transforming consequences of an engineer's labors is regarded; and yet one would not be surprised if one learnt that great individual engineers—such for instance, as the builder of the Forth Bridge—were among the most unassuming of men.

I propose to give a brief account of such of the communications to section A, as may be expected more particularly to interest the readers of this journal. It should be always clearly apprehended that when one man gives an account of another's work that other is in no sense responsible for or bound by what is said. It ought to be absurd to have to point this out, but experience shows that it is not unnecessary; and it is especially necessary to call attention to the fact in connection with a hasty report of a great number of papers, written without notes and without the respective authors' knowledge or supervision. However carefully one may attempt the task some errors are bound to creep in, and were it not that in process of time all these papers will be published in authentic form by their writers, one would not be justified in making the attempt. But persons not able to be present may find even a partially correct account of what went on at the meeting better than none at all.

First, then, the section was happy in having for its president a man exhibiting an altogether exceptional combination of qualities —profound knowledge, great originality, mathematical and experimental skill both of the first order, quickness of comprehension, and a ready wit. The address with which he opened the business of the section was not unworthy of the man. Its subject was that greatest of all physical subjects, "The Ether," and it largely consisted in a glorification of the quite recent experiments of Dr. Hertz in Berlin, whereby Professor Fitzgerald shows that the existence of an ether is raised out of the rank of a very probable hypothesis, which it has long been, into the domain of demonstrated facts. He hints also that certain outstanding problems concerning the structure and properties of the ether can most probably be answered by a further discussion and repetition of experiments like those of Hertz. Our engineering friends ought not to sneer at the prominence given to such a refined abstraction or hypothetical figment as the ether may seem to some of them to be, for it is by its means they drive all electric motors, it is it they use in dynamos and transformers of all sorts; it is the ether which transmits their signals, whether telegraphic or telephonic; and, though this may appeal to them less forcibly, it is through the action of the ether that mankind is enabled to see. Not to mention the as yet incompletely verified hypothesis that it is of ether that engineers and all other material substances are composed.

On Friday morning, the serious electrical business of the section began, and Professor Rowland exhibited his most recent photographs of the solar spectrum, obtained by a yet more nearly perfect concave grating which he had just completed. The photographs exhibited at a former meeting by Professor Rowland had far eclipsed anything previously accomplished; but those now shown were still better, and represent an extraordinary stage of perfection. They are by far the most magnificent things of the sort ever seen. The special appliances in Professor Rowland's laboratory at Baltimore for this work are so perfect and convenient, that the whole solar spectrum can be photographed on an immense scale in the course of a morning. Terrestrial spectra, such as that of iron, can be photographed for purposes of comparison at the same time on the same strips of glass.

It may be hastily thought that such a subject belongs primarily to optics, but it is not so. Ingenious mechanical devices and optical theorems are made use of in obtaining the result, but the influence of the result is more felt in other sciences. The existence of such a standard of wave lengths and permanent measurable records of atomic vibration reacts upon several of the sciences. It reacts upon astronomy by furnishing a statement of the present condition of sun and stars, with which future observations may be readily compared; upon chemistry by exhibiting the relations among the vibration numbers of the elements, whereby hypotheses as to the construction and compound nature of our elements may be tested; and it reacts upon electricity by affording us some knowledge of the precise way in which the ether is disturbed by electric oscillations in the substance of the atoms as well as by the motions of electrically charged atoms themselves.

Lord Rayleigh followed, with an account of an exceedingly delicate and difficult experiment on the question whether an electric current through a liquid influences the velocity of light therein. It is well known that when an electric current flows through an electrolyte an actual transfer of matter accompanies it—two opposite transfers, in fact, as evidenced by the continuous appearance and escape of the travelers, one at each electrode. It is also known by a refined experiment of Fizeau, confirmed by Michelson, that when a beam of light travels down a stream of moving matter its speed is slightly increased, whereas if light travel against a stream of water it is slightly retarded. These things being so, it may be held as probable that whenever the two ions taking part in an electrolytic current differ in momentum a slight effect may be exerted on the velocity of light traveling with or against the current. But then, according to the calculations of Kohlrausch, confirmed by some experiments of the present writer,[2] the speed of the electrolytic ions is extremely small, the quickest being 30 microns per second, or about four inches an hour, for an applied slope of potential of one volt per centimeter.

The effect of such a creep as this was not what Lord Rayleigh looked for. It was quite within the range of possibility that the existence of an electric current in an electrolyte should so disturb the ether inside it as to produce quite a notable change in its index of refraction. Were such an effect discovered it would be a distinctly new fact, not taken account of or even rendered probable by existing theories, and it is very well to have the question experimentally examined, and to a certain extent set at rest.

The method adopted was a beautiful interference arrangement of Michelson, whereby a beam of light is split up into two halves,

1. From the *Electrician* (London).

2. Birmingham British Association Report, 1886, p. 393.

which are sent along a certain route, or circular tour, in opposite directions are then recombined into one again at the point whence they originally split off, and are examined by a magnifying eye-piece. The result is a set of interference bands more or less well defined. Tubes containing dilute sulphuric acid supplied with an electric current are then placed along the route taken by the two half beams of light, so that one-half the beam will be helped and the other half hindered by the current, if it produce any effect at all. The thing looked for is to see if the interference fringes shift along microscopically when the current is supplied, stopped, or reversed. The result is negative, and by considering carefully how much of an effect could have been certainly perceived if it had existed, the definite statement is made that a current of intensity one ampere per square centimeter through dilute sulphuric acid does not affect the velocity of light in its own direction by so much as one part in 13,000,000, or by 15 meters per second.

There are two ways of experimenting. One is to order expensive and highly polished optical banks and other apparatus from an instrument maker; the other, to rig up an arrangement with odd bits of glass, cement and portions of telescopes. The born experimentalist adopts the latter plan; considering beforehand where exactness and steadiness is essential and where it is unnecessary, and accommodating his means to his end with forethought and localized precision. It is by this latter mode of experimenting that the just quoted result has been obtained.

A couple of papers by the present writer followed. One, on the "Measurement of Electro-magnetic Wave-Lengths," the other, on the "Impedance of Conductors to Leyden Jar Discharges." The point of the first paper was to bring forward a case of electric resonance whereby pulses rushing to and fro along a couple of long insulated wires of certain length, synchronized with the known oscillations or alternations in a discharging Leyden jar circuit connected to them. The experiment is thus analogous to an acoustic experiment known by the name of Melde, wherein a tuning fork attached to a long stretched silk string throws it into synchronous vibrations when everything is properly adjusted. And just as the length of the sympathetic string is half the wave length of the sound emitted by the vibrating fork, so the length of each wire in the electrical analogue is half the length of the ethereal waves emitted by the discharging Leyden jar. These waves being essentially light, except that they are much too long to affect the retina. If Hertz had not simultaneously been experimenting in very similar directions, the interest of these experiments might have been greater, but as it is they are perhaps mainly interesting as affording a confirmation of the theory of Kirchhoff, Thomson, and Heaviside, regarding the rate of propagation of telegraphic impulses along a wire. These pulses travel at a speed always a trifle under the velocity of light—under certain perfectly known conditions very much under; but in the most favorable case of two thin parallel wires, transmitting exceedingly rapid oscillatory disturbances (the case of the above described experiment), the velocity of the pulses is, according to theory, exactly the velocity of light; and so it comes out in the experiment. The length of the waves emitted by the Leyden jar circuit can be calculated directly one knows the capacity of the jar and the self-induction of its circuit; the length of the waves sent along the wires can also be observed experimentally; the two determinations are found to be in close agreement.

The following data may be of interest:—

A microfarad condenser, discharging through a good conducting coil of one sec-ohm, gives a current alternating 159 times a second, and emits ether waves 1,200 miles long.

A gallon Leyden jar, discharging through a stout wire suspended round an ordinary sized room, emits waves between 300 or 400 yards in length, its current alternating at the rate of a million per second.

A pint Leyden jar, sparking through an ordinary pair of discharging tongs, gives a current of 15,000,000 alternations per second, with ether waves some 20 yards in length.

An ordinary electrostatic charge on a conducting sphere two feet in diameter, if disturbed in any way, will surge to and fro at the rate of 300,000.000 vibrations a second, emitting waves a yard long.

Electric charges on bodies of atomic dimensions, if able to oscillate at all, would vibrate thousands of billions of times a second, and produce ultra-violet light.

The maximum amplitudes of current given in these several cases can also be stated if the initial difference of potential be given. For instance, the microfarad case charged to a volt will have a current amplitude of one milliampere; the pint jar case charged to give an inch spark will give a discharge current of maximum strength 2,500 amperes.

The second paper by Professor Lodge, "On Impedance of Conductors," has to do with the obstruction offered by conductors of different sizes and materials to sudden rushes of electricity. A series of experiments on the E. M. F. needed to force the contents of a Leyden jar, under given circumstances, through a wire of measured length and thickness arranged in the form of a circle (a single turn about a yard and a half in diameter being usually employed) are briefly described. The numerical results obtained are then compared with the theory of Clerk-Maxwell and Lord Rayleigh, and are found to be in very satisfactory agreement.

The noteworthy thing about these sudden rushes, or violently alternating currents, is that they keep wholly to the outer surface of a conductor, and accordingly the obstruction they meet with has next to nothing to do with either the specific resistance or the magnetic properties of the material. A number of quantitative determinations have been made which will be published elsewhere.

The reason why these alternating or rapidly-varying currents keep to the outside of a conductor is merely because the outside affords the easiest path. If they penetrated its substance like steady currents do, it would have to be magnetized and demagnetized in concentric cylinders by them, and this would cause delay and obstruction. By keeping to the outside they avoid having to do this. It is true that they thereby throttle the conducting area open to them very considerably. They would meet with much less frictional resistance if they permeated the whole sectional area of the wire, but then, for these very rapid variations, frictional resistance is of far less consequence than the inertia-like obstruction of varying magnetization; and, on the whole, they find it better to escape the inertia by keeping to the outside, even at the expense of a throttled and highly resisting path. The whole thing is a compromise, and currents of slower rates of alternation will penetrate deeper, always taking the course which reduces total obstruction to a minimum, until we come to steady or slowly-changing currents, to which the inertia effect of magnetization matters next to nothing, while friction matters just as much to them as to any of the others; these, therefore, will flow through the whole cross-section of the wire with complete uniformity. Regret was expressed both by Lord Rayleigh and by the President that Mr. Oliver Heaviside, who had done so much in the theory of these matters, was not present to join in the discussion.

Next came three papers by Sir William Thomson, the third of which, as connected with the foregoing subject, it is convenient to take first. Its title is, "Five Applications of Fourier's Law of Diffusion, illustrated by a Diagram of Curves, with Absolute Numerical Values," and its subject-matter is the accentuation of the analogy and complete mathematical equivalence existing between the different kinds of diffusion, so that the method suitable for treating one enables problems in the others to be solved. The best known cases of diffusion are:—(a) *The diffusion of substance*, as when a heavy salt solution creeps up from the bottom of a vessel of water until it becomes, in a century or two, thoroughly mixed; or when a scent diffuses in the air; (b) *the diffusion of momentum*, as when motion is transmitted from one part of a viscous fluid to the rest, this being the process by which tea can be stirred, and by which winds and whirlpools are brought to rest some time after the exciting cause has ceased; (c) *the diffusion of energy*, better known as the conduction of heat, a frequently quoted consequence of its laws being the gradual penetration of an alternating disturbance deep and deeper into the substance of a conductor—as, for instance, the diurnal and annual fluctuation of temperature finding their way down into the crust of the earth, so that at a certain depth one could find evidence of heat waves six months behindhand; (d) *the diffusion of electric potential* in the conductor of a submarine cable, worked out long ago by Sir William Thomson as one of the problems to which Atlantic telegraphy gave rise, and by the solution and complete understanding of which rapid submarine telegraphy became practicable; and (e) *the diffusion of electric currents* in the substance of a homogeneous conductor.

It is this last kind of diffusion which is evidently most interesting Sir William at the present time, and he does justice to Mr. Oliver Heaviside's labors in connection with it.

I have been saying above that a very rapidly alternating current keeps to the outside of a conductor, just as a very rapidly alternating force applied to the surface of water in a trough (say by means of a flat board lying on it made to vibrate horizontally) would only succeed in moving the surface water; but this is not a complete account of the matter. When an alternating cause acts at a surface its effect penetrates in waves of diffusion through the mass, dying out according to a certain law of decay. If the alternations are slow the depth of penetration may be very great, as, for example, heat waves in the earth's crust; if they are excessively quick the depth of penetration may be very small indeed. And so for any given frequency of alternation, there is a specifiable depth at which the substance of the medium will appreciably take part in the action, and beyond which no noteworthy effect is produced. The problem, then, is to determine this depth for such rapidities of oscillation as are most common in practice.

The modern supply of alternating currents for secondary generators would seem to have a frequency of something like 150 complete alternations per second, and Sir William Thomson reckons that the depth to which these disturbances penetrate into the substance of a copper conductor is about 8 millimeters, so that portions of the conductor beyond this distance from the surface are almost useless. Hence manifestly conductors for powerful alternating currents should be hollow tubes or flat bars, or separated wires, and the useful thickness of flat copper bars

adapted to carry the present rapidity of alternating currents will be about 6 millimeters, or, say ¼in.[1]

Of the other two communications of Sir William Thomson it is not easy to give an intelligible account without introducing technicalities; but inasmuch as they afforded a text for a great deal of discussion, both in and out of the section, I must try and give a general notion of what they are about. Their titles are, "A Simple Hypothesis for Electro-magnetic Induction of Incomplete Circuits: with Consequent Equations of Electric Motion in fixed Homogeneous or Heterogeneous Solid Matter," and "On the Transference of Electricity within a Solid Conductor." It is not often that the public are admitted to the genesis of scientific ideas, or are allowed to witness a development of opinion going on before them. But in the presence of Sir William Thomson this is no new thing. At his Baltimore lectures a few years back the whole University turned itself with enthusiasm into a research society, and many germs of discovery flourished or faded during the few weeks those lectures lasted. Then, the main topic was an elastic-solid theory of light. Now, we may observe a further step, and without abandoning an elastic-solid theory, which in some form or another is a necessity, Sir William is assimilating, and criticising, and extending, Maxwell's electrical theory. Finding in it certain apparent excrescences and redundancies, he seeks to lop them off and keep only that which is essential. Long-standing students of both Thomson and Maxwell join in, and throughout the meeting there is, among the *dii majores*, discussion and keen competition to see through the fog of symbols, to disentangle their real physical meaning, and to find a right and proper position for the half lopped-off apparent excrescences of Maxwell.

The main point under discussion relates to the mode and rate of propagation of electrostatic potential as compared with electro-magnetic potential. Electro-magnetic disturbances correspond to shearing strains in an elastic solid; they travel through the ether with the velocity of light—the lines of magnetic force spreading broadside on—and about them there is no difficulty. Difficulties begin with the propagation of electrostatic displacements, which correspond to the disturbances possible in an ordinary fluid; longitudinal not transverse disturbances having to do with incompressibility instead of rigidity, disturbances which in ordinary matter we call *sound*.

Suddenly confer upon a conductor an electric charge: in all directions there is experienced a rise of potential equal to $\frac{Q}{r}$. How did that potential reach any given place? Was it by end thrust, or pulse of longitudinal compression, like sound? and, if so, at what rate did it travel? Maxwell assumes the ether to be absolutely incompressible, and, if so, the rate of propagation of disturbances corresponding to sound waves in it is infinite. Longitudinal pulses are not, strictly speaking, *transmitted* at all through a medium of infinite incompressibility, they are simply felt at all distances instantaneously.

That ether is *enormously* incompressible is proved (so it seems to the writer, and he has probably acquired it insensibly through the pores from Maxwell) by an experiment which is best called the "Cavendish experiment," referred to (in a poverty-stricken form) in French books by the name of Biot, and popularly known as the "outsidedness" of electrostatic charge. It is also proved (again to the mind of the writer) by the fact established by Laplace that gravitation, if transmitted at all, is transmitted with a velocity too great to be ascertained at present, and certainly much greater than the velocity of light. But that anything is *infinitely* incompressible is an assertion which it is impossible to make on the basis of any experiment whatever.

Accordingly, Helmholtz has taken into account the possibility of a slight compressibility, and has generalized Maxwell's equations by the introduction of a symbol, k, expressing this compressibility. Helmholtz's equations, therefore, enable this quantity to have any value which experiment may hereafter determine for it, including the possible value 0, which would reduce his theory to Maxwell's again. It is the value of this constant, k, the compressibility of the ether, which the president referred to in his address as hoping to be able to deduce by a further analysis of the experiments of Hertz.

But now, directly a possibility of compression and a finite velocity for longitudinal waves is introduced into the ether, a long outstanding difficulty in the theory of light—a difficulty from which it was hoped the electrical theory would be free, though the ordinary elastic-solid theory is not free—at once makes its appearance. This is the old friend (or enemy) of undulatory theorists, the wave of longitudinal compression, or the "pressural wave," as it is sometimes called. Indeed, in the form of a pressural wave - the instantaneous transmission of a thrust to infinity —it must come in even to an incompressible ether, if the transmission of electrostatic potential occurs by end thrust.

This electrostatic potential is denoted in Maxwell's equations by the symbol Ψ, and so the attempt to get rid of it and do without it in the general equations of an electro-magnetic field was referred to by the president as the "murder of Ψ." Many deaths, and many bringings to life, this unfortunate symbol suffered in the course of the week, and I would not like to say that its fate is even yet decided. On the last day of the meeting Rowland and Fitzgerald seemed to come to an understanding, but whether Sir William will coincide with it, or will upset the whole thing once more, remains to be seen. As they put it the matter is now like this: The propagation of electrostatic potential does not go on by end thrust at all; it is not really analogous to a pulse of longitudinal compression, though it is apparently and superficially so; and accordingly its rate of propagation depends not at all on the compressibility or incompressibility of the ether, a question on which it has nothing to say one way or the other. An electrostatic field is not developed *sui generis*, but is always the consequence of a previously existing electro-magnetic one, which, on subsiding, leaves it as its permanent record.

Plainly, an electrostatic field cannot arise without the motion of some electricity, either with or through a conductor. Now, whenever electricity moves, it at once has magnetic properties—its motion generates a magnetic field. When the motion ceases the field at once subsides, and in subsiding it may produce a succession of diffusing and dying away induction currents in neighboring conductors; or it may, if the circuit be an incomplete one, leave a permanent vestige of itself in the dielectric as a field of strained ether—this state of strain being what we call electrostatic potential, and the field being familiar to us as an electrostatic field.

Generating it in this way, all distinction between rate of propagation of electrostatic and electro-magnetic potential vanishes, they both travel together with the velocity of light; or rather, the thing which travels is the magnetic potential, and its permanent effect *in situ* is the electrostatic potential.

Thus, once more, the difficulty of a longitudinal or pressural wave disappears from the electrical theory of light, into which it had seemed to intrude itself, and Ψ is left to enjoy "a long and useful career," though it is not permitted an infinite or any other rate of propagation in its own proper nature. The question of the incompressibility or compressibility of the ether thus remains unanswered, and, as it would seem, unanswerable, by any such experiments as those of Hertz, or by any experiments on the rate of transmission of electrostatic potential. If any one asks how soon will the pull of a suddenly electrified body be felt at a distance, one may answer, "As soon as the charging spark is seen." But if it be asked at what rate electrostatic potential travels, the answer is that it does not travel, but is generated *in situ* by the subsidence of a magnetic potential which travels with the velocity of light.

It must be understood that the last word has by no means been said on these great problems, and that what I have here written must be digested with salt. It is proper also to record the conviction expressed by the president that most of these refined points would probably be found mathematically treated somewhere in the writings of Mr. Heaviside.

On Saturday, the principal communication was one from Professor Hicks on "A Vortex Analogue of Static Electricity," wherein an idea concerning the ultimate nature of electrostatic attraction is promulgated, which promises to have the most vital influence not only in electrostatics, but in electro-chemistry and theories of valency in general. These points came out most strikingly, not on Saturday, when the paper was read, but at a later stage on the Wednesday following. It so happened that, by reason of the section meeting on this Wednesday an hour earlier than usual, several of the authors failed to turn up, and the sitting threatened to collapse. The section, however, promptly requested its president to fill up the time by telling them the present state of the controversy concerning the elimination of Ψ from the general equations of the electro-magnetic field—the equations concerned with electro-magnetic wave propagation. Professor Fitzgerald at once responded by telling us, not about Ψ, but about Hicks; calling attention to a few ideas which the vortex analogue of static electricity had suggested to him. Professor Hicks joined in with fresh suggestions, and in about 10 minutes of to and fro conversation the most splendid possibilities of future theory, avenues of light permeating the ultimate facts of chemistry, as the ramifications of a lightning flash permeate the atmosphere, were opened up. One may attend many British Association meetings without hearing a "desultory conversation" such as this; one may organize discussions and endeavor to secure them, but they are by no means certainly so procurable. Like genius they must arise spontaneously, or not at all, and woe be to the president who nips them in the bud.

The main point in Professor Hick's communication was a statement of the way in which, under certain circumstances, a hollow vortex may arise between two bodies which are being separated in a perfect fluid. These hollow vortices, or whirls, or cyclones, differ from ordinary vortices in having as their core a stagnant portion of fluid, or an empty space, and their motion is what is known as irrotational—that is, there is no spin at every point of the liquid. The consequence of the centrifugal force of the whirl is a reduction of pressure at the centre, as meteorologists well know is the case with atmospheric cyclones, and as anyone may see in an ordinary plug wash hand basin. The effect of this reduced pressure at the axis of the whirl is to enable the cir-

1. These numbers are not authoritative.

cumambient fluid to press the two bodies towards each other, and thus to give rise to a measurable attraction. The mathematical laws of hollow vortices are found by Hicks to be such that they distribute themselves over the surfaces of bodies precisely like lines of electrostatic force, and they urge the two bodies together with a force varying inversely with the square of the distance. Thus they obey the laws of electrostatic attraction, and every hollow vortex may be called a line of force. Their ends abutting on the surfaces of the bodies will be analogous to, and will represent, the phenomenon called "electrostatic charge;" and however far the bodies are separated these "charges" remain constant. The aspect of the whirls being opposite, as seen from either body, their ends may be styled positive and negative respectively.

If a third body is introduced between the original pair, some of the whirls separate into two, with their ends abutting on the intermediate body, which thus acquires equal positive and negative charges; it is subject to induction. And so on. All the main phenomena of static electricity may be imitated by the behavior of these hollow vortices in a perfect fluid, and they take the place of lines of force.

Now comes the chemical application. The circumstance which is essential for the generation of these hollow vortices, when two bodies are separated from contact, is that during contact they shall be connected by an ordinary vortex filament with its ends abutting one on each body. Such a filament causes throughout the medium a state of rotation which results in the generation of a hollow vortex at the point of contact as soon as that contact is broken. When the distance between the bodies (which may now be called atoms) becomes considerable, the original vortex filament is so pulled out as to exert very little effect, and it may be neglected; but the hollow vortex generated by it increases in energy as the bodies are separated against its attractive influence, and retains its cross-section unimpaired.

The original vortex filament joining the atoms in contact thus corresponds to what chemists call a "bond" or unit of chemical affinity. There may easily be more than one such bond, perhaps as many as six, joining two bodies; it is a question of stability, and the limit of number can be worked out by vortex mathematics. The hollow vortex which makes its appearance when the atoms are separated corresponds to the electrostatic charges and lines of force existing between the monad constituents of a dissociated molecule.

If there are two bonds with the same sense joining two atoms in contact, then when they are separated two hollow vortices will be found between them, corresponding to the two units of electrostatic charge which are found on a dissociated dyad atom. Any one hollow vortex may easily split up so as to distribute its ends properly over the surfaces of the bodies as they are further separated, but its essential properties are unaltered by fission; and the exact dependence of the electrostatic charge on the original number of dissociated bonds is an evident re-statement of Faraday's law of electrolysis.

But there is the possibility that two original bonds should whirl in opposite directions, and in that case they would neutralize each other's effect at the point of contact and generate no electrostatic charge at all when the bodies are separated. Such a mode of combination may correspond to what chemists style "molecular," and atoms dissociated from such molecules would be intractable to electrical influence—the compound would not be an electrolyte.

There is no need for the original vortex filament to reach across from one body to another; its ends may quite well abut both against the same body, and in that case we shall have a self-satisfied pair of units of chemical affinity. Another body coming into the neighborhood of such a looped bond may open it out; and it may do so in either of two ways; it may break it in two in the middle, thus linking itself to the first body by two bonds of opposite sign; or it may let one end slide from the original body on to itself, thus effecting a monad style of combination, giving rise to electrified atoms when dissociated.

Furthermore, of the self satisfied or looped bonds possessed by a body there may be a considerable number—possibly a very great number; it is again a question of stability to be worked out, but not yet worked out, by hydro-dynamics; and the loops may some of them be long, so as to project a good distance from the body, while some may be quite short and close to its surface.

The long loops will correspond to the important bonds able to intersect and combine with another atom at a considerable distance—that is, at a high temperature; while the shorter and closer loops can only be expected to act at close quarters, *i. e.* when the temperature of the substance is low. Thus it may turn out that at very low temperatures all manner of complex aggregations are possible.

At first sight it might seem as if high temperature favored chemical combination, but that is a mistake. High temperature is often necessary to break up existing molecules, and so to enable fresh and often more powerful combinations to form; but high temperature is a dissociating and expanding influence *per se*, and it is at low temperatures that the most unwieldy complexes are formed.

So far nothing has been said concerning the nature of the atoms themselves; but assuming that they can be formed of groupings of circular vortices, it becomes of interest to see what combinations are stable, and therefore possible. It has been shown that the greatest number of columnar or cylindric vortices which can waltz round one another in stable equilibrium is six; but Mr. Hicks surmises that, the circular form being a little more stable, a combination of as many as seven *rings* may be able to group together, threading each other in regular succession, and forming a single atom of a definite kind, up to which there are six grades, constituting other and simpler kinds of atoms. To form a more complex atom than this, these seven rings must be treated as a single atom, which can begin to link itself with from one up to seven others; and then the grouping will begin again; so that the properties of the elements and their atomic weights will fall into octaves. Should this view be borne out by hydrodynamical calculation the meaning underlying Mendelejeff's law will have a good chance of displaying itself; or rather, it will have been completely displayed.

So busy was section A, that on Saturday, when many of the sections took a holiday, it split itself into two in order to get through its work; and even so, one of the sub-sections continued sitting till 3 P. M.

Towards the end of the day the report of the electrolysis committee was read. It was a short statement of the work that had been done by the members during the past year, and was followed by a few papers. The communication of Lord Rayleigh concerning the velocity of light in electrolytes should have formed part of this report, and would have done so had the secretary of the electrolysis committee (O. J. L.) looked after its interests as he ought.

Professor Fitzgerald and Mr. Trouton have continued their investigations into the accuracy with which electrolytes obey Ohm's law, and are now able to state that if there is any discrepancy for sulphate of copper it is less than three parts in a million. This is a very satisfactory result, the obtaining of which means a good deal of careful work as well as an ingenious method.

An account of Dr. Gladstone and Mr. Hibbert's experiments on the conduction of alloys and solid sulphides followed, wherein it was shown that the conductivity of fusible alloy was mainly and probably wholly non-electrolytic, while sulphides of the form M_2S were most of them electrolytically decomposed by a current.

Professor Armstrong and Dr. Arrhenius contributed some critical remarks on the general theory of electrolysis, which, however, in their absence, were taken as read, and will be printed with the report.

Mr. Shaw communicated a paper sent by Dr. Richarz, from Berlin, containing an account of some experiments on the polarization E. M. F. of a voltameter with very small electrodes, wherein he switched the voltameter cell quickly from a charging battery to a galvanometer by means of a Helmholtz pendulum, and thus obtained values of the polarization decidedly lower than had been previously obtained with point electrodes by Buff. Richarz seeks to explain the difference by neglected heat effects.

The time of Tuesday was so largely taken up with a discussion on lightning conductors that Dr. Fleming's two papers "On a Form of Standard Resistance Coil," and "On a Commutator for Charging and Discharging a Condenser at a Known Rate," had to be taken as read.

Mr. Glazebrook stated the results of his continued most careful investigation into the state of the old B. A. standards of resistance. Examining them with the most minute accuracy and plotting their results over a certain range of temperature, their curves all nearly intersect at a temperature where they are supposed to be correct. They do not, of course, exactly intersect at a point, but they agree very well; and, what is of most interest, they have preserved their relative values among themselves ever since they were first exactly compared by Dr. Fleming in 1875 (?). All except one, which has recently begun to show distinct signs of aberration, probably by reason of some slight defect in insulation. Since these coils are the world's material standard of resistance at the present time, it is most desirable to know that they are constant; and, inasmuch as they are made of different materials and have preserved their relative values, it is practically quite certain that their absolute values have remained unchanged.

The committee on electrical standards are undertaking experiments with a view to construct a reliable standard of electrostatic capacity, and are examining some air condensers constructed and measured some time ago by Dr. Muirhead.

Mr. Preece's paper on C. G. S. units is really a communication to the electrical standards committee, asking them to sanction the use of the term "joule" for the work done by a watt in a second, as proposed by the late Sir W. Siemens. The committee have acquiesced in the suggestion, and the Joule is, therefore, now 10,000,000 ergs, or a coulomb-volt. They have also, at Mr. Preece's instigation, sanctioned the name "therm" for the water-gramme-degree-centigrade unit of heat, the absolute unit of heat being either the erg or the joule, according to taste. The joule will make a unit of heat of very convenient size, because 4.2 such units will equal one therm. In other words, the absolute specific

heat of water will be henceforward 4.2, and the specific heat of other things in proper proportion.

Mr. Preece further proceeds to lament the unfortunate circumstance which has caused the ampere to be one-tenth of the C. G. S. unit of current instead of one unit. He is sanguine enough to hope even yet for a change in this matter; but the feeling of the committee was not with him, though they all felt the inconvenience of the present state of things.

Another matter which he has succeeded in inducing the committee to take up is a re-determination of the specific resistance of pure copper. It appears that copper is now supplied commercially by manufacturers which eclipses the standard as tested by Matthiessen, and which was known in his day as pure copper.

Sir William Thomson described a determination of the product μK for air, commonly called a determination of the velocity of electro-magnetic waves "v." A certain condenser had its capacity measured electro-magnetically at Glasgow with the use of one of Sir William's new standard current weighing instruments, and it was then measured electrostatically in London by Professors Ayrton and Perry. The resulting value of "v" comes out from the experiments, so far made distinctly too low, something like 293,000 kilometers per second, with a possible total error of 1¾ per cent.; as compared with the 299.5 thousand kilometers per second determined by Professor Rowland, with very perfect condenser, absolute electrometer and ballistic galvanometer. Most of the German determinations of "v" slightly exceed 300; most of the British determinations slightly fall below it. If the method now described is to give a reliable value, it will doubtless be repeated many times, and the somewhat large margin of error reduced.

In connection with absolute determinations of great accuracy, it is surprising how many difficulties come in, such as seldom have to be thought of in ordinary laboratory observations. Considering all the care that has been taken in the construction of standards of length, it is rather depressing to be told by Professor Rowland that the standard meter is an uncertain quantity, and that the various meter standards in use differ by so much as one-tenth of a millimeter, or a hundredth per cent. People accustomed to speak glibly about obtaining an accuracy of a tenth or a hundredth per cent. in their measurements little know what they are talking about. Probable errors of as much as one per cent. in an absolute measurement are much more frequent than is by many persons suspected.

Mr. Glazebrook has been most carefully and for a long time examining the specific resistance of mercury in glass tubes, a measurement which has revealed unexpected difficulties and distinct though minute discrepancies from previous determinations. There can be little doubt that Mr. Glazebrook's results are the most accurate yet obtained, and he states that the true ohm is equal to the resistance of a square millimeter column of mercury 106.29 centimeters long.

We are here getting down to the limit of accuracy with which the standard meter itself is known.

Sundry minor communications may be hastily glanced through. A method of utilizing an electric current for calorimetry, by Professor Stroud and Mr. Gee, really belongs to the subject of heat. Mr. W. N. Shaw exhibited an arrangement for measuring the average temperature of an extended body, consisting of wires imbedded in a long ribbon of india-rubber which could be wrapped about the body, and the resistance of the wire measured. The wire is made in two branches, each of a different metal, so that a differential galvanometer balance can only be exactly obtained at one particular temperature, and the compensation needed to correct any outstanding error is used to obtain the temperature. It is said to give it to about $\frac{1}{100}$th of a degree. Mr. J. Brown, of Belfast, exhibited some pretty and curious branching figures made by an electric spark on an ordinary photographic dry plate. Mr. Lant Carpenter stated some particulars concerning the E. M. F. and internal resistance of Gassner's jelly-filled battery cells, as measured by Mr. Rimington; and last, though not least, Sir William Thomson described some experiments made in his laboratory by Mr. Tanakadaté on the magnetization of soft iron bars of different lengths in a uniform field. This paper the writer regrets not having heard.

And now we have cleared the course for the lightning rod discussion, which excited a good deal of interest, and which really was a discussion, in which many prominent members of the section took part, and on which much more might have been said had there been time.

The discussion is being reported in this journal pretty nearly verbatim; but out of such a mass of matter it will be difficult for anyone to pick out the salient points of difference between the opposite camps, and it may be useful to bring them into more marked relief.

The opposite camps may be styled the Practical *vs.* the Theoretical. On the one side we find constructors of lightning rods, members of the lightning rod conference, meteorologists, and engineers; a miscellaneous body of great experience headed for the time being with efficiency and good humor by the president of Section G, who has necessarily in his official position an enormous number of lightning protectors under his supervision.

On the other side we find some laboratory experiments, and a theory of the alternating character of a discharge, combined with a mania for talking about self-induction or electro-magnetic inertia, and for poking this idea into a lot of places where it does not naturally seem to fit; excluding its influence, however, from other places where one would expect to find it, such as the interior of an iron rod.[1]

If views and statements so founded are to make headway against the experience of practical men, and to gradually introduce reform into existing procedure, it must be by reiterated statement and discussion, and after gradually acquired further experience under circumstances and conditions arranged to test the new views on a large scale. On the other hand, if the self-induction mania has no sound basis in fact, the surest way of destroying it is to bring it into the arena and expose it to conflict. Hence it is that the organizing committee of Section A arranged for the opposite camps to meet and skirmish at Bath.

The combat was not waged to the death, the lists being cleared before the combatants were half exhausted, so that it is quite possible they may meet again on some other arena. Meanwhile, the points at issue may be summarized thus: selecting those statements of Mr. Preece and his supporters which seem most generally accepted, or likely to be accepted, on that side; and numbering the opposing statements so as to correspond with them. No statement is here quoted or suggested which, to the writer, seems entirely absurd; because absurd statements may easily be made in debate without sufficient thought, and because such statements are not likely to be generally or weightily accepted, even if pressed by their propounder.

Statements made in the Practical Camp.	*Statements made in the Theoretical Camp.*
1. Properly constructed lightning rods never fail. When existing rods fail it is because there is something the matter with them—usually an insufficient earth.	1. Rods as at present constructed, though frequently successful, may and do sometimes fail, even though their earth is thoroughly good; the reason being that they offer to a flash a much greater obstruction—a much worse path—than is usually supposed; an obstruction to be reckoned in hundreds or thousands of ohms, even for a very thick copper rod.
2. Leyden jar discharges have nothing oscillatory or alternating about them, or at least the existence of such alternations is an unproved assumption.	2. When a Leyden jar is charged it corresponds to a bent spring, and its discharge corresponds to the release of the spring. Its discharge current alternates, therefore, in the same way and for much the same reason as a twitched reed or tuning fork vibrates. The vibrations decay in either case because of frictional heat production, and because of the emission of waves into the surrounding medium. A single spark of a Leyden jar, examined in an exceedingly fast revolving mirror, is visibly drawn out into a close succession of oppositely-directed discharges, although its whole duration is so excessively minute.
3. Even if Leyden jar discharges should turn out to be oscillatory, there is no reason why lightning flashes should be of the same character. Lightning flashes have an apparent duration, and transmit telegraph signals, deflect compass needles, and do other things which alternating currents could not do.	3. A lightning flash is a spark between cloud and earth, which are two oppositely electrified flat surfaces, and the flash corresponds therefore to the internal sparking between the two plates of a great air condenser. All the conditions which apply to a Leyden jar under these circumstances are liable to be true for lightning. Sometimes the resistance met with, either in the cloud itself or in the discharger, may be so great that the spark ceases to be oscillatory, and degenerates into a fizz or rapid leak; but there can be no guarantee that it shall always take this easily manageable form; and it is necessary in erecting protectors to be prepared for the worst and most dangerous form of sudden discharge. The apparent duration of a lightning flash is due to its frequently multiple character, and indicates successive discharges, not one long-drawn out one. Nothing that lightning has been found to do disproves its oscillatory character; because Leyden jar discharges, which are certainly oscillatory, can do precisely the same.
4. The one thing needful for an efficient lightning protector is conductivity, sufficient conducting power to convey the whole charge quickly and harmlessly down to the earth, with which the conductor must make elaborate contact.	4. Although some conductivity is necessary for a lightning conductor, its amount is of far less consequence than might be expected. The obstruction met with by an alternating or rapidly varying discharge depends much more on electro-magnetic inertia or self-induction than upon common resistance. So much obstruction is due to this inertia that a trifle more or less of frictional resistance in addition matters practically not at all. It is very desirable to have a good and deep earth in order to protect foundations and gas and water mains from damage, and in order to keep total impedance as low as possible.

1. Professor Lodge's original lectures "On the Protection of Buildings from Lightning," were reprinted in *The Electrician*, June 22 and 29, July 6 and 13, 1888.

5. No danger is to be feared from a lightning conductor if only it be well earthed and be sufficiently massive not to be melted by a discharge. All masses of metal should be connected to it, that they may be electrically drained to earth.

5. The obstruction offered by a lightning rod to a discharge being so great, and the current passing through it at the instant of a flash being enormous, a very high difference of potential exists between every point of the conductor and the earth, however well the two are connected; hence the neighborhood of a lightning conductor is always dangerous during a storm, and great circumspection must be exercised as to what metallic conductors are wittingly or unwittingly brought near or into contact with it. When a building is struck the oscillations and surgings all through its neighborhood are so violent that every piece of metal is liable to give off sparks, and gas may be lighted even in neighboring houses. If one end of a rain-water gutter is attached to a struck lightning conductor the other end is almost certain to spit off a long spark, unless it also is metallically connected. Electric charges splash about in a struck mass of metal, as does the sea during an earthquake or when a mountain top drops into it.[1] Even a small spark near combustible substances is to be dreaded.

6. The shape of the sectional area of a conductor is quite immaterial; its carrying power has nothing to do with extent of surface; nothing matters in the rod itself but sectional area or weight per foot run, and conductivity.

6. The electrical disturbance is conveyed to a conductor through the ether or space surrounding it, and so the more surface it exposes the better. Better than a single rod or tape is a number of separate lengths of wire, each thick enough not to be easily melted, and well separated so as not to interfere with each other by mutual induction.

The liability of rods to be melted by a flash can be easily over-estimated. A rod usually fails by reason of its inertia-like obstruction, and consequent inability to carry off the charge without spittings and side flashes; it very seldom fails by reason of being melted. In cases where a thin wire has got melted, the energy has been largely dissipated in the effort, and it has acted as an efficient protector; though, of course, for that time only. Large sectional area offers very little advantage over moderately small sectional area, such as No. 5 B. W. G.

7. Points, if sharp, should constitute so great a protection that violent flashes to them ought never to occur.

7. Points, if numerous enough, serve a very useful purpose in neutralizing the charge of a thunder-cloud hovering over them, and thus often prevent a flash; but there are occasions, easily imitated in the laboratory, when they are of no avail; for instance, when one upper cloud sparks into a lower one, which then suddenly overflows to earth. In the case of these sudden rushes, there is no time for a path to be prepared by induction, no time for points to exert any protective influence, and points then get struck by a violent flash just as if they were knobs. Discharges of this kind are the only ones likely to occur during a violent shower; because all leisurely effects would be neutralized by the rain-drops better than by an infinitude of points.

8. Lightning conductors, if frequently tested for continuity and low resistance by ordinary galvanic currents, are bound to carry off any charge likely to strike them, and are absolutely to be depended upon. The *easiest* path protects all other possible paths.

8. The path chosen by a galvanic current is no secure indication of the course which will be taken by a lightning flash. The course of a trickle down a hillside does not determine the path of an avalanche. Lightning will not select the easiest path alone; it can distribute itself among any number of possible paths, and can make paths for itself. Ordinary testing of conductors is therefore no guarantee of safety, and may be misleading. At the same time it is quite right to have some system of testing and of inspection, else rust and building alterations may render any protector useless.

9. A certain space contiguous to a lightning rod is completely protected by it, so that if the rod be raised high enough a building in this protected region is perfectly safe.

9. There is no space near a rod which can be definitely styled an area of protection, for it is possible to receive violent sparks or shocks from the conductor itself. Not to speak of the innumerable secondary discharges which, by reason of electro-kinetic momentum and of induction and of the curious recently discovered effect of the ultra-violet light of a spark, are liable to occur as secondary effects in the wake of the main flash.

Just one word on the subject of iron *vs.* copper. The writer last year thought and stated that, in so far as the substance of the conductor was magnetized by a discharge, iron would obstruct a lightning flash or any other rapidly varying current enormously more than copper does. But the fact is, that the substance of a conductor is, by sufficiently rapidly alternating currents, not magnetized at all. The current is tubular, keeps wholly to the outer surface, and magnetizes nothing inside. Hence the magnetizability of the substance of the conductor is of no moment at all; and iron, therefore, will do every bit as well as copper. Mr. Preece's experience with half a million iron wire telegraph post protectors leads him to uphold iron as entirely satisfactory. So, on this one point, as well as on the necessity existing for a good earth, a portion of the practical and of the theoretical camps have been able to agree.

Immediately after the discussion Dr. Janssen exhibited some preliminary attempts at photographs of lightning taken with a double-nozzled camera, having two sensitive plates, one fixed, the other revolving 30 times a second.[2] The same flash was depicted on both plates, but on the moving plate it was separated into two or three distinct streaks, showing its multiple character. Each constituent, however, was as clear and distinct on the rotating as on the fixed plate, and had, in fact, exactly the same shape and appearance, so that one could be superposed on the other exactly; thus proving its instantaneous character. The rate of spin was naturally nothing like sufficient to exhibit the alternating character of each constituent.

It is to be hoped that many more photographs of lightning will be taken on this plan, because there are evidently many kinds of composite flashes, and it is an excellent way of analyzing them and correcting the impressions, often erroneous, formed by the eye.

On the whole, the Bath meeting, though not largely attended by the temporary class of members and associates, may be considered, so far as Section A is concerned, as one of the most interesting and important that have ever been held—thanks largely to the excellent arrangements made by the secretaries; and the discoveries of Hertz, referred to by the president in his address, mark a distinct epoch in our acquaintance with electro-magnetic phenomena.

1. *See* "The Eruption of Krakatoa," a pamphlet by E. Douglas Archibald, Tunbridge Wells; or the Report of the Krakatoa Committee.

2. *See* a letter in *Nature*, July 12, 1888.

ABSTRACTS AND EXTRACTS.

PRACTICAL EXPERIENCE IN THE USE OF ACCUMULATORS.

BY LEONARD PAGET.

MUCH—indeed a great deal too much—has been said for and against accumulators. Those interested in commercial sales have extolled these valuable auxiliaries beyond every reasonable limit; disappointed purchasers have decried all accumulator systems. Those who have not yet tried electrical storage have before them only two reliable ways of making judgment—by accepting unbiased and competent authority, or by actual trial. In this view there are here given abstracts of the statements of Professor Köhlrausch,[1] whose name is accepted in Europe as a synonym for accuracy and reliability in electrical work.

The principal advantages of accumulators are the following: They are always ready for use; we know exactly what can be obtained from a charged battery; the efficiency of an accumulator, compared to that of a primary battery is high and especially certain; the internal resistance is extremely low.

The inconveniences may be enumerated as: The accumulators have to be charged before they can be used; they are too heavy to be easily transportable; it is necessary to recharge the accumulators immediately after discharge, to avoid deterioration of the plates; during the last of the period of charging, the bubbles of gas that escape carry with them sulphuric acid which attack metallic bodies in the neighborhood, and also provoke coughing.

The inconveniences of the old systems of accumulators, as for example, the fall of plugs from the lead grids, the buckling of positive plates, have been eliminated. And it appears as if we should arrive in time at the construction of accumulators of which we can guarantee a duration of several years.

Phenomena during charge and discharge with currents of normal quantity.—The absolute value of the electromotive force of an accumulator depends not so much upon its form as upon the quantity of current; it is proportionately lower during charging and higher during discharge as the current is greater.

The values of the E. M. F. vary a little from one cell to another; however, the following mean values apply to the majority of cases. The mean potential difference reaches 2.15 to 2.16 volts during charge, and 1.86 to 1.9 volt during discharge, supposing a normal quantity of current. The ratio of these two values is about 0.87.

There is recovered generally in the discharge 90 to 93 per cent. of the quantity of electricity stored (in ampere hours) during the charge, with the restriction that the interval between charge and discharge does not exceed one to two days. The efficiency of a good accumulator is then $0.87 \times 0.915 = 80$ per cent.

The normal quantity of current is determined by the dimensions of the free surfaces of the positive electrodes. The density

1. Annalen-Wiedemann, vol. 34, p. 583.

of the current per square decimeter varies, according to the form of accumulator, between 0.5 and 0.7 ampere.

Measurement of internal resistance.—This measurement which offers certain difficulties by reason of the small value of the resistance and the high electromotive force, may be most easily made during charge and discharge. Let e be the electromotive force, p, the difference of potential at the terminals, i, the current, r, the internal resistance; there obtains

during the charge............ $p = e + i r$
" " discharge.......... $e = p + i r$.

The E. M. F. of the accumulator on open circuit is measured immediately before the charge and before the discharge; and the difference of potential at the terminals, p, is subsequently measured just after closing the charging or discharging circuits.

By substituting the values obtained in the above equations, there are given the corresponding values for the internal resistance. The resistance of the element discharged is a little greater than that of the element charged, because of the sulphate of lead formed and because of the lower conductivity of the acid solution.

Phenomena occurring during irregular charging and discharging.—The capacity of the accumulator increases proportionately as the quantity of the current in charge and discharge decreases. With irregular working, the value of a discharge depends not only on the preceding charge but also on previous charges and discharges.

Reciprocally, a prolonged discharge with a small current weakens the subsequent discharges effected with a normal current. The causes of these anomalies lie probably in a residual formation still insufficiently explained.

The efficiency of the accumulator may, in particular cases, fall as low as 60 to 70 per cent. and even surpass 100 per cent. It is necessary to avoid as far as possible all discharges with a current of small quantity.

It is necessary never to leave accumulators discharged, because there is then produced sulphate of lead at both electrodes, which increases the resistance of the cell. If accumulators remain long out of use, it is necessary to charge them from time to time until gas is given off; it is also recommended to charge and discharge them from time to time normally.

If there is reason to suppose that a cell of the battery does not work in a normal manner, the accumulators should be examined first in groups, and then one by one of the defective group by rapidly measuring the electrical pressure.

Installation of new cells.—It has been the practice hitherto for the maker to deliver the plates and vases separately. As soon as they arrive, the plates should be washed with a small mop slightly damped; if the plates are separated, they must be reconnected and soldered to the connecting bars. The solution of acid is then to be prepared by employing rain water and the commercial sulphuric acid known as pure acid. The vase is to be so filled as to moisten the plates only as the liquid rises in the vase. A normal charge is then to be given and continued to the end without interruption. If the full capacity is not obtained in the first charges, the battery is to be surcharged until the desired capacity in ampere-hours is attained.

Professor Köhlrausch cites the case of accumulators that should have given 44 ampere-hours with a discharge of 6 amperes, and that actually gave only 30 ampere-hours; by surcharging them for 12 hours, they subsequently gave permanently a capacity of 47 ampere-hours.

It is advisable to cover the accumulators with a plate of glass to avoid the diminution of the solution by evaporation and the carrying over of the liquid by development of gas (spraying). The proper quantity of liquid may be renewed once or twice with water, for its density may vary without inconvenience between wide limits. It is requisite, however, from time to time to bring the liquid up to its normal density; to this, the battery is to be divided into groups of 5 to 10 cells, and the average density of the liquid of each group determined; thus the missing quantity can be prepared and such density given to it as that when mixed with the liquid remaining in the accumulators will give a normal density. Each (discharged) accumulator is then, by means of a pipette, refilled with liquid, and afterwards charged.

It is necessary never to completely empty the accumulators, because the negative electrodes heat rapidly on contact with air in consequence of the energetic oxidation of the finely divided lead. If the negative plates are to be removed, the most simple plan is to place them in an atmosphere of illuminating gas.

Charging accumulators.—The best machines for charging accumulators are shunt-dynamos. It is very convenient to intercalate a rheostat in the circuit, The following example illustrates the advantages. Suppose it is wished to charge a battery of 50 accumulators of 0.005 ohm resistance with a current of 20 amperes. The total resistance of the accumulators being 0.25 ohm, it is requisite that the tension of the machine should exceed that of the battery by 5 volts; now the tension of the battery rises gradually from 105 to 115 volts, and it is necessary that the machine follows in the same ascending ratio from 110 to 120 volts, which may be caused to occur by varying the velocity of the machine or the quantity of the shunt current in the field magnets. It is much better practically to insert a resistance of 0.5 ohm in the circuit and to diminish the resistance little by little, so as to keep the current constant at 20 amperes. This auxiliary resistance diminishes, besides the variation of current produced by variation in the speed of the machine.

CORRESPONDENCE.

NEW YORK AND VICINITY.

The Board of Electrical Control.—Dr. Wheeler's Lecture at the Young Men's Christian Association.—Resignation of Mr. C. O. Mailloux, from the Julien Co.—The Complaint against the U. S. Illuminating Co.—The Brooklyn Bridge Lights.—Electric Lighting for the "Puritan."—Permit Granted Edison Company by Brooklyn Aldermen.—Re-opening of the Telegraph School of Manhattan Elevated Road.—Annual Receipts of Elevated Roads.—Mayor Hewitt's Answer to Ex-Gov. Cornell's Letter.—An Electrical Storm.

THERE are evidences of an effort on the part of the Board of Electrical Control to systematize their details and methods for more effective work. As an electrician recently remarked: "They are just beginning to find out what they don't know."

Mr. C. O. Mailloux, who has been the consulting electrical engineer of the Julien Electric Co. since its organization, has resigned his position.

Dr. Schuyler S. Wheeler's lecture upon "Electricity and its Modern Applications" at the Young Men's Christian Association Rooms, on October 5th, was so well attended that several hundred persons were unable to gain admission. The lecture was illustrated by a number of experiments showing the effects of induction, the advantages of electric motors for power purposes, the operation of transformers, etc. The East River Electric Light Co. furnished circuits for arc and incandescent lamps. Dr. Wheeler was assisted by Mr. Francis B. Crocker. In the course of his remarks, Mr. Crocker spoke earnestly of the opportunities afforded young men in the electrical field.

The complaint of President Hess, of the Board of Electrical Control, against Mr. Eugene T. Lynch, president of the United States Illuminating Co., charging that company with maintaining a nuisance, by keeping its wires above ground, came up for examination at the Jefferson Market Police Court, on October 2d, but on account of the absence of the attorneys for the prosecution, Justice Duffy adjourned the examination for one month.

There has been some objection raised by navigators to the electric lights upon the Brooklyn Bridge, and a demand made that they be screened. The lighthouse board claim they are a violation of their regulations. District-attorney Walker, however, in a communication to the attorney-general states that no rule referring especially to the Brooklyn Bridge, has been adopted, and there is no existing rule covering the matter, and if there was it is not clear that there is any provision which makes it an offence to maintain lights that are a hindrance to navigation. He therefore recommends that Congress pass an act prescribing a punishment for disobedience to the orders of the lighthouse board, and that the board make some definite order on the subject.

President Howell, of the bridge trustees, believes there is no necessity for screening the lights. He says that the bridge has been so lighted for five years, and during that time no pilot has ever made complaint; the only protests received were from the same men who objected to the construction of the bridge.

The new Sound steamer "Puritan" is to be lighted by 1,600 Edison lamps.

The Brooklyn aldermen have passed an ordinance giving the Edison company the right to do business in that city. The newspapers who are opposed to Governor Hill's re-election allege that it was clearly a campaign trick—Governor Hill having vetoed a legislative act giving that company the same privileges in return, it is said, for political support.

The management of the elevated railroads have decided to reopen the Chatham square school of telegraphy. They propose giving their gatemen instruction so that in case of strikes or other trouble, operators can be provided. The present operators object to this, alleging that it is but a scheme to reduce their wages.

The mayor has requested the elevated roads to put on more trains, which they have agreed to do. One is fortunate at present if he secures a seat at any time during the day. The yearly receipts of the Manhattan Railway Co., as reported to the state comptroller, are $8,519,019, an increase of $629,944 over the past year.

There is a decrease of receipts reported on all the surface roads with the exception of the Third avenue, which shows a slight increase.

Col. J. A. Corby, who is largely identified in telephone, electric light and railway interests along the Missouri river, has been in the city for several days.

In declining to enter into an elaborate controversy with ex-Governor Cornell, over the question of electrical conduits, Mayor Hewitt writes:—

"I can only say that every man has his limitations. I am conscious of my own lack of ability to take in the whole compass of human enterprise, and I am compelled to confine myself to the consideration of such matters as are brought before me day by day, and to decide such questions as I am compelled to answer, according to the best of my judgment. This duty I have performed, and shall continue to perform to the end of my term; but I have no time to discuss with you or any one else, matters which I do not understand and have not time to study."

On the morning of the 17th, this city was treated to a magnificent meteorological display, the like of which it is said has never before been seen in this city. All persons who looked out of window about half-past six, saw a memorable spectacle. A lurid yellow, flaming sky, suggestive of a general conflagration—a sort of portent that would have terrified the mass of men some hundred or two years ago. Although the storm was of short duration, serious trouble was experienced upon all the telegraph wires, the atmospheric disturbance being almost entirely electrical. Lightning struck in front of the Washington Building, No. 1 Broadway, throwing off the cover of a subway man-hole and tearing up the pavement for some distance around. Investigation revealed no damage to the subway.

NEW YORK, October 29, 1888.

PHILADELPHIA.

Underground Work Going Forward; a Comprehensive Plan to be Carried Out.—Harrison Bros. & Co.'s Suit against the Telegraph Companies.—The Leber Regulating Incandescent Lamp.—The Electric Light Question Before Councils.—The Keystone Company's Suit.—The Bell Telephone Co., of Philadelphia, will Erect a New Building.

THE much talked of, but long delayed, movement for the burial of telegraph and telephone wires in this city has begun in earnest, and the Western Union Telegraph and Bell Telephone companies propose to spend $250,000 to put all their wires underground between the two rivers and Vine and Fourth streets. The work has already begun, and the wires east of Fifteenth street will be underground before many months shall have passed.

Those west of Fifteenth will go under the surface of the streets after the others shall have been buried. The contract for the building of the conduits has been awarded to Charles A. Porter. Already a conduit of brick has been laid on the south side of Market street from the Delaware River to Fourth street. It is 4 feet in width and 8 feet high. Within this conduit has been placed 49 iron pipes, each 3 inches in diameter. Each pipe will hold 100 wires, so that the capacity of the conduit will be 4,900 wires. The conduit will extend out Market to Thirteenth, up Thirteenth to Arch, out Arch to Fifteenth, and down Fifteenth to Market, and thence to the Schuylkill River. The conduit on Market street will be known as the trunk line, and at every other cross street, branch conduits will be laid to carry the wires north and south.

The plan that will be followed in making connections with buildings has been approved by city councils and the board of highway supervisors. The wires will be carried underground to the centre of each block, where a tall pole, 75 or 100 feet in height, will be erected, and from this point the wires will be run into the rear parts of the buildings. For instance, the block bounded by Second, Third, Chestnut and Market streets will be fed from a pole erected in Elbow lane. The block bounded by Second, Third, Chestnut and Dock streets will receive its wires from a pole erected in Carter's alley, midway between Second and Third streets. By this plan all the telegraph and telephone wires on the streets will be buried out of sight, and the objectionable poles removed as well.

The location of the trunk line on Market street will compel the removal of the Bell Telephone Co.'s exchange from Fourth and Chestnut streets to a place on Market street, not far from its present location. Mr. W. B. Gill, general superintendent of the Western Union Telegraph Co. for this district, said yesterday that the change would be a great improvement, and that it would be pushed to completion as rapidly as circumstances will permit. He said the business centre of the city will, in a comparatively short time, be completely free from overhead wires.

"This is the largest and most complete system that has ever been undertaken in any city in the country," said Mr. Gill. "While in Chicago recently I was driven over that city in every direction, and I can say there are more poles and wires in that city than in the same amount of territory in Philadelphia. While it is true that in a limited portion of that city there are no poles, wires are strung overhead from house to house. In no city of the United States has there been so earnest an effort made for placing wires underground as in Philadelphia. The Edison Electric Light Co. is placing miles of underground tubes and wires in the Penn company's trenches in addition to its own, and the city itself, through its electrical bureau, has an underground system that will compare favorably with that of any other city. While the electrical companies have done much toward the development of the underground systems, too much praise cannot be bestowed upon Mayor Fitler for the time and labor he has given to the placing of wires underground. It is a well-known fact that several of the underground systems adopted in Chicago have proved failures, and it is hoped and believed that the improved conduits now being laid in this city will be successful.

The long-pending litigation, in which Harrison Bros. & Co. are the complainants and the Franklin, the Atlantic and Pacific and the Western Union Telegraph companies are the defendants, was recently under argument before Justice Bradley in the U. S. Circuit Court.

The contract out of which the suit arose was made twenty-one years ago. It appeared that when the Insulated Lines Telegraph Co. was about to be merged into the Franklin company, in 1867, Harrison Bros. & Co. made an agreement with the Franklin company to erect at its own expense a wire between New York and Philadelphia. The firm was given the priority of the use of this wire for the transmission of despatches for themselves and four other parties who were in the position of the firm's licensees. This contract was to remain in existence for ten years and then the wire was to be the property of the Franklin company, and the firm was to pay $600 per annum for its use. The Franklin company eventually became the property of the Western Union, which endeavored to terminate the arrangement, and the matter finally drifted into a legal controversy.

In 1882 the firm brought equity proceedings for the purpose of restraining the telegraph companies from depriving them of the use of their private wire. Much testimony was taken, and this now forms the subject-matter of the spirited argument of counsel. The construction of the wire in the first place, it is claimed, cost the firm $10,000, and the $600 rental has been promptly paid since 1877. The privilege is a very valuable one at present. The question before the Court is whether the contract still holds good or whether it must be considered terminated. The argument will be resumed this morning.

The working of the Leber regulating incandescent light were shown a short time since in the *Ledger* job office to a number of gentlemen interested in electric lighting. The invention is one by which the brilliancy of the light may be increased or decreased by the turning of a key, the same as an ordinary gas light attachment. The light shown was regulated to show any degree of brilliancy from one sixteenth of a candle power to one hundred candle-power. The exhibition was a highly successful one, and the new light will be taken in hand by a number of Philadelphia capitalists.

A resolution was recently adopted in councils providing for the appointment of a special joint committee to investigate the electric light question. The city, the resolution stated, pays to electric light companies $129,000 a year for 755 arc lights. This was claimed to be excessive, as the city, with a plant of its own costing $300,000, could supply light to 2500 or 3000 lamps at an annual expense of $90,000. The companies were also charged with furnishing only 1200 candle-power to many of the lamps, while their contracts call for 2000 candle-power. In view of these statements the committee was instructed "to investigate and report, with such recommendations for legislation as may be decided necessary to remedy the evils presented and further the best interests of the city." Messrs. Jones, Graham, Freeman, Thornton and Moffett were appointed as select council's half of the committee. In speaking of the resolution, Mr. Graham said that the electrical committee had considered the matter and had found that the plant would cost $400,000, and the annual expense would be more than $90,000. "Still we don't get the light we are paying for," he admitted.

Court of Common Pleas No. 1 has decided not to pass on the question of law involved in the suit of the Keystone Light and Power Co. until action shall have been taken by the electrical committee of councils.

The company wants the city restrained from interfering with its underground work. Judge Allison said that the plaintiffs should try and use some means to obtain a decision from the electrical commission, but the Court would not allow the purposes of justice to be defeated by inaction, and would take a long delay to be a refusal to grant the privileges asked for, and would then adjudicate the points involved.

The Bell Telephone Co. has purchased the buildings Nos. 406 and 408 Market street, and will erect thereon a new structure, four stories high, which will be used as its exchange. The removal from Fourth and Chestnut streets is made necessary by the burial of the "trunk line" of telephone wires along Market street. The company cannot take possession of the property until January 1st, 1889.

PHILADELPHIA, October 17, 1888.

.... I SET very little value on the speculations of even our admittedly greatest scientific men, unless they be supported by experiment.—*S. Alfred Varley.*

.... I DO not think that in actual practice there is an average waste of 10 per cent. in the use of converters when they are properly designed.—*Professor George Forbes.*

BOSTON.

The New England Electrical Exchange.—An Inspector of Electric Wires Proposed.—Meeting of the New England Electrical Exchange.—Interference with the Work of Firemen by Overhead Wires.—A Cross Causes Danger to the Wooden Dome of the Central Fire-Alarm Station.—Controversy at Newton between Gas and Electric Interests.—Monthly Statement of the American Bell Telephone Co.—Testing the Long-Distance Telephone Lines.

THE New England Electrical Exchange held its quarterly meeting in the rooms of the Boston Electrical Club, No. 66 Boylston street on the afternoon of the 8th inst. President P. H. Alexander occupied the chair, and delivered an address reviewing the work of the exchange, pointing out its increasing usefulness. A letter from Professor W. A. Anthony, of the Mather Electrical Manufacturing Co., of Manchester, Conn., a member of the examining board, suggesting alterations in the plan of licensing, was read, and the alterations adopted. As the legality of the licenses issued by the exchange had in some cases been questioned, it was voted to obtain a charter of incorporation, and a committee of three was appointed for that purpose.

Saturday evening, the 6th, a fire in the six-story warehouse numbered 411 and 413 Atlantic avenue and 74 and 76 Purchase street, necessitated three alarms and caused a loss of fully $50,000, one-fifth of which is on the building. There is no doubt that the loss would not have been nearly so great had not the mass of electric light wires in front of the building on Atlantic avenue interfered so seriously with the work of the firemen. These wires made it impossible for the men to stand on the ladders without receiving shocks from the electric fluid. One fireman came in contact with an electric light wire while he was standing on a ladder, and received a severe shock, which necessitated his removal to the City Hospital. The injuries of other firemen from the same cause was slight. At last the electric light companies shut off the currents of electricity, and then the firemen went to work with a will and soon had the fire under control.

At the meeting of the board of aldermen on the 8th inst., a special committee of three members of the board of aldermen was appointed to inquire into and report what action can be taken by the board of aldermen to protect the lives of firemen and property from the danger arising from overhead electric wires.

The regular session of the aldermen was held Oct. 15, and the following communication received from the mayor:—

City of Boston,
Executive Department,
Oct. 15, 1888.

To the Honorable, the City Council:

GENTLEMEN:—

I submit herewith a communication from the Boston Board of Fire Underwriters in relation to overhead wires. I have long felt that an inspector of overhead wires was a necessity and will be a necessity until some practical system of placing all wires underground is ascertained. I, therefore, heartily indorse such an appointment, and believe that such an official should be attached to the fire department. This department relies on overhead wires for the efficient performance of their work, and these wires should be protected. The firemen should also be protected in the performance of their duties from the danger of overhead wires. The irregular way in which most wires are put up should be remedied, all wires not used should be removed, and all overhead wires should be under the charge and direction of an inspector, whose duty it would be to see that they were so placed as not to endanger life or property. I am satisfied this can be done, and hope that the city council will give it favorable consideration.

Respectfully submitted, HUGH O'BRIEN, Mayor.

The communication of the Boston Board of Underwriters is as follows:—

Boston Board of Underwriters,
No. 70 Kilby street,
Boston, Oct. 13, 1888.

To His Honor the Mayor, and the Honorable City Council of the City of Boston:

GENTLEMEN:—

The undersigned, representing the Boston Board of Fire Underwriters, respectfully petition your honorable body to take into consideration the advisability of creating the office of inspector of electric wires. While at the present time the board which the undersigned represent undertake an inspection and supervision of electric light wires for the purpose of preventing loss to life and property by unsafe methods of running these wires, it is beyond their power to in any way regulate the running of telegraph, telephone and other wires through the streets or over the tops of buildings. In the absence of all inspection and regulation these wires are run in such a manner as best suits those who put them up. They are frequently brought into dangerous proximity with electric light wires, and at other times are run in such a manner as to greatly interfere with the work of firemen endeavoring to extinguish a fire. In the opinion of your petitioners great gain would result to the citizens of Boston if the running of electric wires of all kinds could be placed under strict official supervision, compelling the various electric companies to give notice in advance of their intention of running wires, and making it necessary that they should obtain the approval of the official inspector of the route selected before they could proceed with their work. In this way many of the dangers which are now from time to time encountered might be obviated.

We would, furthermore, suggest that a license fee might be charged the various electric companies which would be amply sufficient to defray the cost of a thorough inspection.

Trusting that your honorable body will take this public matter into favorable consideration, your petitioners subscribe themselves,

J. EDWARD HOLLIS, President,
OSBORNE HOWES, JR., Secretary,
Boston Board of Fire Underwriters.

The matter was referred to the committee on fire department.

The board of aldermen on the 21st inst. passed over the mayor's veto by a vote of eight to four the order granting Henry E. Cobb, Royal M. Pulsifer, Henry E. Chapman, and their assigns, leave to open up the city streets for the purpose of laying conduits for electric wires. This is stated to be virtually granting a monopoly of the underground conduit system of Boston.

On the night of the 1st inst. a cross with a heavily charged wire caused the burning out of the repeater in the dome of the City Hall building, and there was imminent danger to the large wooden dome. It is evident that a wooden structure is not adapted for the needs of the central fire alarm station, and the subject of changing the same into a substantial stone tower is being agitated.

The controversy between the Newton and Watertown Gas Co. and the Newton Electric Light and Power Co., was the subject of a hearing before the gas commissioners on the 11th inst. The gas company had the contract for lighting the City of Newton, and furnished 800 gas and 700 naphtha lamps. The contract expired last spring, and has been renewed for short periods twice since, pending legislative action on the right of the company to employ electricity. The electric company in the meantime has put in 70 arc lights, and offers to supplant gas and oil with 1,500 incandescent burners at less cost. The city continues both systems, pending the decision of the gas commissioners.

The statement of the out-put of telephones by the American Bell company for the month ended Sept. 20, is as follows:—

September—	1888.	1887.	Increase.
Gross output	3,920	4,110	*190
Instruments returned	2,156	2,152	4
Net output	1,764	1,958	*194
Dec. 21 to Sept. 20			
Gross output	41,660	40,651	1,009
Instruments returned	16,802	19,815	*3,013
Net output	24,858	20,836	4,022

*Decrease.

On the 15th inst. the long-distance telephone lines already constructed were tested from the executive offices of the American Bell Telephone Co. Conversation was carried on with Buffalo, and intermediate points. The results obtained were satisfactory, although it was stated that a few incidental faults remained to be remedied.

BOSTON, October 16, 1888.

CHICAGO.

Telephone Regulation Still Occupying City Councils.—Oscar G. Clark, an Electric Light Employe, Killed while Testing Lamps; the Coroner's Investigation.—Chicago Electric Club Notes.—Electric Railway Notes.—Lighting of the Columbia Theatre, Chicago.—New Incorporations and Corporation Notes.

THE telephone question is a source of endless trouble in the city council. The aldermen are continually fighting over it, and when they let the matter slide for a short time the papers pitch into them and cry boodle. The two ordinances introduced some months ago for the regulation of the business of the telephone company came up for consideration as special orders at the council meeting, October 8th. The first ordinance provided that the rental of instruments should be $95 the first year, and $85 each succeeding year, or $75 on three years' contracts; the other measures provided that no limit should be put on charges, but that the company should pay 2½ per cent. of its gross receipts into the city treasury. The former ordinance was recommended by the committee on licenses; the latter was a minority report of the same committee. The proposed measures were discussed, and amid some excitement the minority report was substituted for the majority report. Confusion began to reign and the aldermen adjourned without taking action.

The Chicago *Tribune*, in commenting on the action made a direct charge of bribery against the aldermen who voted to substitute the minority for the majority report. It asserted that the 2½ per cent. tax would bring into the city treasury $19,000. While by the readjusted schedule proposed by the majority report subscribers would be saved $275,000. The matter came up again at the meeting of October 15th. There was a radical change of sentiment. The aldermen after considerable discussion passed the ordinance, which provides that the rental shall not be more than $95 the first year, and $85 for each succeeding year, or $75 on three years' contracts. The measures also contained provisions requiring the company to furnish the central offices of city departments instruments without charge, to furnish instruments for the police and fire departments at $5 per year, and to bury a part of the circuits.

A great deal of pressure had been brought to bear on the aldermen to induce them to take this action. The druggists' association had adopted resolutions urging the council to reduce rates.

When the matter was under consideration Mayor Roche intimated his belief that the ordinance was illegal. Subsequently he said: "It is the opinion of the law department that the ordinance is invalid. I will not sign it. It is now simply a question whether the company will accept it. It scarcely seems probable that they

will do so, inasmuch as it compels them to charge less by $50 a year on three years' contracts than they are now obtaining. It has 30 days in which to accept the ordinance."

The officers of the telephone company were reticent on the question, president Phillips said he would not make any statement until he learned what action the mayor intended to take. He thought the mayor might suggest amendments which would make the ordinance more satisfactory. The city press still harps on the question. The *Tribune*, for example, urges the company to accept the ordinance and expresses the belief that the company by a refusal will make manifest an intention to defeat the will of the people by corrupt means. The *Daily News* is dissatisfied because the council did not reduce the rental to $50 per year. It is understood that Mayor Roche is in favor of taking such action as will bring the telephone question before the Supreme Court in a test case in order that the rights of the city on the one hand and of the company on the other may be speedily determined.

Oscar G. Clark, an employé of the Thomson-Houston company, was killed by an electric shock in the repair room of the company, October 3d. Clark was testing lamps at the time. The lamps were on a 50-light dynamo. The load varied from 44 to 46 lamps. The switchboard is located in the ceiling. Clark found that one lamp did not work satisfactorily. He had his left hand on a binding post of a lamp, and in his right hand he had a short stick with which to throw the switch. He could not reach the switch with the stick, so without removing his left hand from the binding post he jumped slightly. As he did so his right arm struck against the lamp lifting it slightly from contact with the hanging wire. At the same time his arm came in contact with the wire, thus short-circuiting the lamp. He received the full current. He groaned, staggered backward and fell upon the floor. The employés rushed to his assistance and endeavored to revive him. Meanwhile two physicians were summoned. They labored for two hours to resuscitate, him but without success. Beyond gasping twice the unfortunate man gave no sign of life. Clark was a bright ambitious young man with a decided tendency to make experiments on his own account.

The inquest was held October 5th. Two employés and George Cutter, the electrical engineer in charge of the department, were sworn. It was proved conclusively that the deceased had been instructed times without number, not to do the very thing which had caused his death. Mr. Cutter said an hour before the accident he had urged upon Clark the necessity of being extremely cautious in testing the lamps. He had also instructed the deceased not to adjust the lamps but to report simply whether they were working satisfactorily.

Professor Barrett asked whether the accident might not have been caused by a ground. Mr. Cutter was positive that it could not have occurred in such a way. The circuit was a short one, used only for testing purposes. It had been examined before and after the accident, and the resistance was found to be over 1,100,000 ohms. Mr. Barrett asked if Mr. Cutter had a certificate from the city inspector, permitting him to operate the plant. He replied in the negative. The plant, he said, was not complete in the first place, and in the second place he had been informed by the inspector that the ordinance relating to inspection was not enforced in testing rooms of electric light companies. Mr. Barrett was not satisfied, and insisted that the coroner submit to the jury a copy of the city regulations relating to operating electric light plants. The attorney of the Thomson-Houston company objected, but the coroner complied with the request. The jury brought in this verdict:—

"We, the jury, find that Oscar G. Clark came to his death from an electric shock while opening a switch in the Thomson-Houston company's works; also, that we, the jury, believe that the company is greatly to blame in not complying with the law."

Mr. Cutter said subsequently "The work in the shop is not of a temporary character. The circuits are all well put up. I should be glad to have any electrician look through the place and see the precautions against accident which I have taken. I had absolute cut-outs and had crossed my connections so that if a person touched two lamps he could not receive more than two-lamp tension. I had practically reduced the danger of fatal shock to a break in the circuit or an escape to ground."

A gentleman commenting on the fatality said, "The tendency of the bright young fellows in the business is to try experiments and to become careless. They are cured by receiving one good shock. I have known several young men thoroughly cured of all tendency in this direction by receiving a 500 volt shock."

The death of Clark was the fourth caused by the electric current in Chicago.

It seems to be the unanimous feeling in the Chicago Electric Club that more pretentious quarters should be secured. Most of the members incline toward a club house. The first fall meeting was held October 1. President S. A. Barton was in the chair for the first time. He made no formal address, but in three or four little speeches indicated his desire to see the club in better quarters. It was supposed that the matter would be settled October 15, but the meeting announced for that date was postponed by the board of managers. It is asserted on the one hand that the club cannot become a large and prosperous organization unless it secures a club house of its own. In order to obtain quarters of this kind it would be necessary to remove from a central location. Here another argument is presented. It is said if the club is located at a distance from the heart of the city the members would not visit it frequently; in other words, that the club would fail to accomplish the very objects for which it was formed—to promote a fraternal feeling among those interested in electrical matters and to secure the discussion of live topics pertaining to electrical science. The decision of this question will have an important bearing on the future of the club.

Theo. P. Bailey, manager of the railway department of the Chicago office of the Thomson-Houston company, has secured the contract for constructing the electric road at Alliance, O. The company has also secured the contract for installing an electric road for the Topeka (Kan.) Rapid Transit Co. The road will be 14 miles in length, and the cost of the installation will be considerably over $200,000.

The Columbia Theatre, Chicago, is now lighted throughout by electric lights. Nine hundred incandescent lamps and 20 arc lights are used. Many new features have been added of a kind to adapt the new system particularly well for effective stage work. C. C. Haskins, city inspector of electric lights, would not permit the location of an arc lamp in the dome unless the greatest precautions were taken to prevent sparks from the carbons causing a fire. The space above the lamp and the sides was lined with asbestos, and a mercurial thermostat located there.

The capital stock of the Central Electric Co., of Chicago, has been increased from $10,000 to $50,000.

The Dieckmann Electrical Co., of Chicago, has been incorporated with $10,000 capital stock. The incorporators are G. F. Dieckmann, Christian Wall, and David Quigg.

The Cutting Electric Alarm Co., of East St. Louis, Ill., has been organized. The capital stock is $8,000. The incorporators are W. H. Cutting, B. C. Graham, and B. Gratz.

The Alton (Ill.) Gas and Electric Light Co., has been incorporated with a capital stock of $60,000. The incorporators are Alvah E. Campbell, John Watt, and Levi Davis, Jr.

The Penrock Battery and Electric Light Co. is giving daily exhibitions of incandescent lighting by primary batteries. The company proposes to enter the field for installing isolated plants.

The Fort Wayne Jenney Co. will install the Slattery alternating street system in Galena, Ill. A converter will be provided for each street lamp.

The Thomson-Houston company, of Chicago, has been awarded a contract for 135 arc lights by the Dallas (Tex.) Electric Light, Power and Manufacturing Co.

CHICAGO, October 20, 1888.

MONTREAL.

Canadian Electric Light Notes.—A Painful Accident to Mr. Sise.—Visitors from the States.—The Federal Telephone Co.—Lectures by Mr. W. R. Kimball.

EVERYTHING electrical, as if in sympathy with the activity in the states, is on the boom in Canada. Especially so is electric lighting. More interest is now manifest here in lighting than ever before.

The Royal Electric Co. report as recent installations a 250 light plant at Granby. Six hundred lights are to be installed in the new Canadian Pacific station, with 12 arcs. The dynamo room is to be removed from the main building, when the special station house shall be completed. Thirty arcs and 700 incandescent lights are being installed in Joiliet by the town. Thirty arcs and 500 incandescents are being installed at St. Johns, P. Q.

They also report 30 arcs sold to the Toronto Electric Light Co., and an increase of 50 lights in the Orangeville plant.

The Edison company also make a good report. They have sold to the Royal City Planing Mills, Van Couver, a plant; and an increase of 50 50-c. p. lamps to the Van Couver Illuminating Co. Valleyfield, has made an increase to 300 lights. The Maritime Pulp Works, Chatham, N. B., have put in 375 lights. The James Crassen Car Works, Coburg, Ont., have placed 300 lights; R. Gardener & Sons, Montreal, have put in 75 lights; Chatham, N. B., has put in 200 20-c. p. municipal lamps. Thompson's shoe factory, Montreal, is running a 200 light plant, supplying themselves and others.

Mr. M. D. Bow has succeeded Mr. Lawson as Canadian agent of the Edison company. Mr. Lawson, however, remains with the company in charge of the factory at Sherbrook.

In the suit of the Edison company, *vs.* the Royal company and others, on the question of infringement, the Edison company have asked a delay until the 10th of November, when the case comes up for decision.

The Royal Electric Co., are making vigorous preparations here for the establishment of a 1000 light alternating plant, and have the foundations under way for a 1000 h. p. station. Only a portion of this capacity is to be used immediately.

The Montreal city authorities sometime ago took up the matter of lighting the city from one or two stations to be established by the corporation. Mr. Badger, city electrician, has handed in his

report and an estimate for 800 arcs and 500 incandescent lamps, of 32-c. p., and places the estimated cost at $280,000 for the erection of a complete system in two stations, including electrical and steam plant.

Much regret and sympathy is felt here on account of an accident occurring to Mr. Sise, at Halifax. While he and a friend were driving in the evening, they were run into by a farmer's wagon. Mr. Sise was thrown out, and his friend also, who, falling on Mr. Size's breast, broke a rib. Mr. Sise arrived home a few days ago, and is now progressing favorably. His friends hope to see him about again as usual very soon.

Mr. T. D. Lockwood was in town a few days ago on a semi-holiday (he never takes a whole one) and a trip through Quebec. Mr. Geo. Manson and Mr. Henry D. Stanley, also favored us last week by a flying visit.

The Federal Telephone Co. have nearly all their poles placed in position and have begun to string cables. Progress is slow however. If they are ready in the spring as is now promised, much will have to be accomplished in a short time.

Mr. W. R. Kimball, of the Royal Electric Co., began recently a series of lectures before the Young Men's Christian Association class. He is a young man of marked talent, and those who have the opportunity of attending, will be well repaid, as he intends illustrating his lectures by numerous experiments.

MONTREAL, October 19, 1888.

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, *11 Wall street, New York city.*

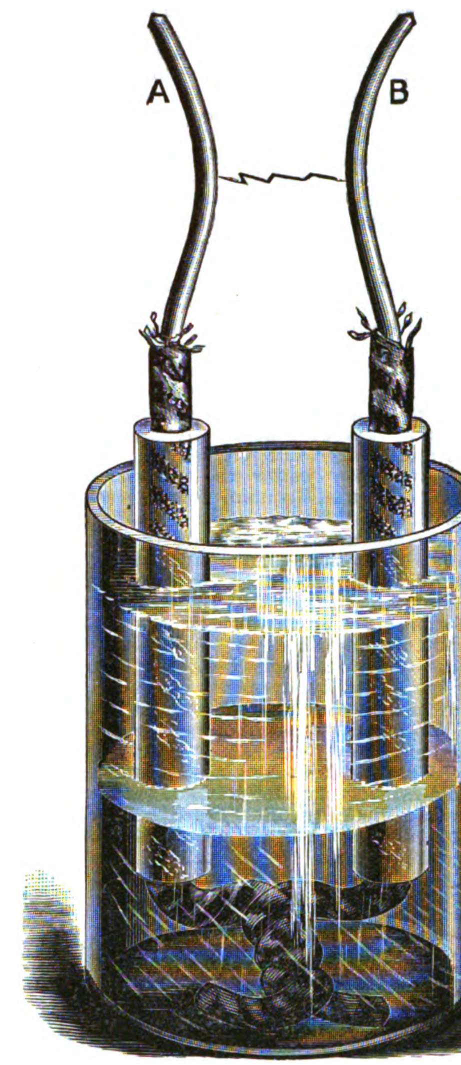
DISRUPTIVE DISCHARGES IN UNDERGROUND CABLES.

[99].—At the meeting of the National Electric Light Association, held in New York some six weeks since, Mr. E. G. Acheson read a paper touching the "determination and the cause and cure of the frequent puncturing of the insulation, especially at the terminals, of lead-encased conductors, when carrying high potential currents." As Mr. Acheson's paper has had a pretty extensive publication in the electrical journals, I offer a few remarks on the determination, the cause and the cure of the evil discussed in it. Mr. Acheson speaks of the trouble as "disruptive discharges." In coiling and uncoiling lead you are liable to open pores. As lead tubing is coiled, the outer surface of the tube forming the circle is elongated and the inner surface compressed, and this condition is enhanced by the comparatively rigid nature of the cable or conductors inside. If the insulation consists of paraffine, which is all broken by the coiling and uncoiling, and a "pinhole" happen to be open to the paraffine, moisture penetrates the lead and paraffine also, and gets to the conductor. If instead of paraffine a mixture of rosin and rosin oil is used, and moisture gets to the mixture, it stops there, because the mixture is semi-liquid and heavier than water; but as lead tubing is drawn over the cable it comes in contact with its textile covering inside; now if moisture reaches the textile covering, the covering will absorb it and it makes no difference whether you use paraffine, asphalt, rosin and rosin oil, or any similar substance.

There is no way of making any vegetable fibre moisture-proof except by surrounding it by some substance that is itself moisture-proof. If we take a piece of lead-encased cable, make a hole no larger than the point of a needle and immerse that portion in water, if the hole goes no farther than to reach the paraffine, it will go to the conductor and the insulation is impaired; similarly if the insulation consists of rosin and rosin oil, the moisture will reach the mixture, but goes no farther, the insulation is not impaired; but if the pore is open to the textile covering which is liable to be in direct contact with the lead, the textile covering will absorb the moisture and insulation is impaired. I have shown this by experiment many times.

Many attempts have been made to lay lead-encased cables across rivers, and every one, to my knowledge, has proved a failure where the insulation consisted of paraffine, although the lead was served with hemp saturated with tar, and further protected with an armor of iron wire; but when rosin and rosin oil were used, and the lead served with a similar outside sheathing, better results were obtained. These cables were used for telephone purposes where feeble currents are employed; how much more liable are such cables to fail when currents of a high potential are used? How many lead-encased cables have failed in this country when used for telephone purposes! Can it be said that they were destroyed by disruptive discharges when they were provided with lightning protectors, point discharges and plate discharges?

Let this be illustrated by an experiment:—A glass jar is about one-third filled with a mixture of rosin and rosin oil, two cotton covered wires are twisted together and the ends separated, as shown in the bottom of the jar; the wires are heated in the mixture to 350 F. before being immersed, then two glass tubes are drawn over the wires, the tubes extending into the mixture below; we then turn water on to the mixture, filling a portion of the jar, as shown in the figure. The wires are supposed to be No. 16 gauge insulated to one-eighth of an inch diameter. Although



the wires are separated from each other where twisted by less than one-eighth of an inch, if we apply the two poles of a Holtz machine at the ends, A and B, we can pass a spark between the bare portions of the wire two inches in length, before the current can be made to pass through the covering of the wires when twisted together. It will be seen how easy it is to protect the insulation from disruptive discharges. Iron pipe is a thorough and radical "cure" or rather preventive of "pinholes." If we substitute paraffine in place of rosin and rosin oil mixture, the water penetrates the paraffine although it has been allowed to cool and become seemingly solid, the insulation between the wires fails.

The cable that I laid for the Pennsylvania Railroad Co., over a year since, embodies these principles; it contains 53 conductors. May 5, Professor Kendall gave the average insulation over 4,000 megohms per mile. Every conductor is in perfect condition. The professor will make another test of the conductors soon, and I will send you the results. DAVID BROOKS.

PHILADELPHIA, October 16, 1888.

.... WILLANS & ROBINSON have actually delivered from a dynamo one kilo watt by the consumption of two pounds of coal per hour, or by the condensation of 20 pounds of steam.—*W. H. Preece.*

.... SPLENDID as are these most successful uses of water power to actuate distant electromotors, it is but a stray stream here and there that has yet been utilized, and countless wealth is still being squandered in all the torrents all over the world.—*Professor Ayrton.*

LITERATURE.

REVIEWS.

The Elements of Electric Lighting, Including Electric Generation, Measurement, Storage and Distribution. By Philip Atkinson, A. M., Ph. D. D. Van Nostrand, New York, 1888.

DR. ATKINSON has written a book that contains for the most part the kind and amount of information on electric lighting and its allied topics that would be desired by, and be useful to, general readers who have not time for bulky octavos, but like to know something accurately about an art and industry so prominent as that which gives the title to this small volume.

In the introduction the author says he desires to set forth "the various facts pertaining to electric lighting in plain language, devoid of technicality and perplexing mathematical formulæ, from which business men, mechanics, and those who have the care and management of dynamos and lamps, as well as general readers, may gain a knowledge of the principles and construction of the apparatus by which this light is produced, and of the nature of that invisible, intangible agency which is its prime cause."

Chapter i. is devoted to the question, What is Electricity? Dr. Atkinson is very confident that it is a mode of molecular motion, and in 13 pages sets forth the reasons for his belief with much cogency and in a very interesting manner. Chapter ii. begins the subject proper of the book, and as befits a work on electric lighting as a commercial art starts off with "Principles of the Dynamo." Chapters iii. and iv. are devoted to "Alternate Current Dynamos" and "Direct Current Dynamos" respectively. "Electric Terms and Units" are treated in chapter v. Perhaps it would have been better to introduce this matter before the chapters on the dynamo, for the sake of readers unacquainted with the terms and definitions employed in describing the construction and mode of operation of the dynamo. A fuller and more elementary explanation of the principles of magnetic induction than Dr. Atkinson has supplied would be to the advantage of the uninstructed reader in acquiring a clear notion of the source of the electric current in a dynamo. Chapters iii. and iv. are amplified by illustrated descriptions of machines as made by several leading electric light companies, fairly presenting the several types now in commercial use.

Following the treatment of the dynamo, a chapter each is given to the arc lamp and the incandescent lamp. Chapter ix., "The Storage Battery," and chapter x., "Electric Distribution," conclude this useful and readable book, with a brief but reasonably comprehensive and satisfactory sketch of the growth and progress of those branches of electric work. Dr. Atkinson's manual can be sincerely commended to the attention of the classes of readers addressed in his introduction.

RECENT PUBLICATIONS.

Brodix's American and English Patent Cases, Vol. VII. Decisions on the Law of Patents for Inventions Rendered by the United States Supreme Court from the Beginning. 21 Howard, 1859—7 Wallace, 1869. Edited and annotated by Woodbury Lowery. Washington, 1888. *The Brodix Publishing Co.* 8vo., law, sheep. 582 pp.

Preparing for Indication; Practical Rules, the Result of Twenty-three Years' Experience with the Steam Engine Indicator. By Robert Grimshaw, M. E. *New York Practical Publishing Co.* Illustrated, 16mo. cloth, 56 pp. Price $1.00, post-paid.

The Pump Catechism; A Practical Help to Runners, Owners or Makers of Pumps of Any Kind. By Robert Grimshaw, M. E. Fourth Edition. *New York Practical Publishing Co.* Illustrated 16mo., cloth, 233 pp. Price $1.00, post-paid.

CATALOGUES AND PAMPHLETS RECEIVED.

The Bridgeport Brass Co. have issued, in convenient pocket form, leather bound, a series of tables showing the stress in pounds on a span of their hard-drawn copper wire for any given dip from 2 to 30 inches, when in a state of absolute rest, and for spans of varying length (100 to 176 feet), and for sizes 10, 12, 14 and 16, by B. & S. and by Birmingham gauges—and 10, 11, 12, 13, 14, 15, 16 and 17, by new British gauge. These convenient tables have been made by Mr. H. D. Stanley, of the Bridgeport Brass Co., from actual tests made by him for the company.

POINTERS.

.... THE scientific student should regard theories as more or less useful tools, and not accept them as articles of faith.—*S. Alfred Varley.*

.... IT was a great step in human progress when man learned to make material machines, when he used the elasticity of his bow and the rigidity of his arrow to provide food and defeat his enemies.—*G. F. Fitzgerald.*

.... SEVERAL years practical experience points to the conclusion that secondary batteries of sufficient mechanical strength and durability cannot yield much more than seven watt hours per pound weight of material.—*A. Reckenzaun.*

.... I REMEMBER revisiting my old schoolmaster, and his saying to me, shaking his head: "So you have gone the way I always feared you would, and are making things of iron and brass to do the work of men's hands.—*Sir Frederick Bramwell.*

.... I THINK there is a needless objection to high speed by engineers in this country. If we have a uniform cylinder of iron revolving, I have no objection to any rate of speed so long as I know the shafting will not give way.—*Professor George Forbes.*

.... THE engineer regards electricity, like heat, light and sound, as a definite form of energy, something that he can generate and destroy, something that he can play with and utilize, something that he can measure and apply.—*W. H. Preece.*

NEWS AND NOTES.

THE TELEPHONE.

THE ordinance authorizing the Cleveland Telephone Co. to place its wires about the Public Square, and in the down-town streets underground is now a law, and the company will soon begin the work of laying the conduits.

THE BELL TELEPHONE CO., of Philadelphia, has commenced the work of putting their wires underground. Lead covered cables are laid in wooden boxes under the streets, and the wires are carried to large poles in the centre of each block, and from there they are distributed to the several subscribers in that block. A large trunk line is being laid in Market street, from river to river. Other lines branch off north and south on each of the main streets. In nearly all the blocks, small streets and alleys provide convenient centres on which to erect the distributing poles. By this system all streets will be freed of wires, as well as roofs of houses, and the network of distribution in back yards and small streets will be so small as not to be objectionable. The ordinance authorizing the laying of these underground wires and erection of poles requires the removal of all overhead wires within five years, but the company expect to complete the work sooner than that.

THE Philadelphia *Record*, of October, says, that connection has successfully been made between Philadelphia and Portland, Maine, a distance of 600 miles, which may be considered another long-distance triumph.

THE Wilmington *News*, Delaware, states that a telephone wire has been erected from the Lewes life station to the station at Chincoteague. Through the communication thus established, many lives can be saved in case of a disaster.

IT is reported by the Montreal *Witness*, of October 4, that the telephone was put to a novel use in Toronto. A citizen who had been summoned to appear at the police court for breach of a by-law finding that he could not appear in person, telephoned the fact to headquarters, admitted his guilt, and was fined $1.00 and costs through the same medium.

THE following is reported by the *American*, of Nashville, Tennessee. A council committee has just framed a new bill, relating to the Cumberland Telephone and Telegraph Co. It practically places the company under control and direction of the board of public works. The company must pay a yearly tax of $1.00 on each set of instruments in use, and must give a bond of $25,000 to indemnify the city against any loss. The bill has passed second reading.

INJUNCTION SUIT AGAINST THE CUSHMAN COMPANY GRANTED.

Shortly after the termination of their suit against the Cushman Telephone Co. (an abstract of which appeared in the ELECTRICAL ENGINEER for September), the American Bell Telephone Co. brought an injunction suit to restrain the Cushman company from continuing the rental, sale and operation of instruments in the State of Indiana. Judge Blodgett rendered his decision October 29th, granting the injunction asked for; not to take effect, however, until January 1st, 1889.

The defendants claimed that the Bell company had withdrawn its instruments from the state upon the passage of a law limiting the rates. Upon this point the court ruled that the fact that complainant's licensees or grantees have withdrawn their telephonic accommodations does not furnish any excuse or any defense for the infringement of these patents by defendants.

THE NEW YORK ELECTRICAL SOCIETY.

A meeting of the New York Electrical Society was held October 24, in the lecture room of the laboratory of Mr. Thomas A. Edison, at Orange, N. J. A paper was read by Mr. A. E. Kennelly, Mr. Edison's chief assistant, upon "Electrical Measurement." Mr. Kennelly's remarks, although largely extemporaneous, covered a wide range of experiment and illustration. He exhibited the new "Ergmeter," of Professors Ayrton and Perry. At the conclusion of Mr. Kennelly's remarks an exhibition was given of the phonograph, after which several of these instruments were placed at the convenience of the society and its guests. About 250 persons were present. The evening was very enjoyable to all present.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

SPECIAL MEETING, OCTOBER 9TH, 1888.

Discussion of Mr. F. J. Sprague's Paper on Municipal Rapid Transit.

THE series of special meetings for the season of 1888–89, was begun October 9.

The meeting was called to order at 8 P. M., by Mr. Ralph W. Pope, secretary, at the house of the Society of Civil Engineers, 127 east 23d street.

Mr. Pope—In the absence of the president, the indisposition of one of the vice-presidents and the desire of another to be excused from service this evening, it will be necessary for you to select a chairman.

On motion of Mr. Jos. Wetzler, Mr. G. M. Phelps was chosen chairman for the evening.

The Chairman—Gentlemen, I am indebted to you for the compliment of being called on to preside to-night. I will ask the secretary to state the programme for the evening.

The Secretary—As most of you are aware, the programme of the evening, as stated in the call issued, is the discussion of the paper on "The Solution of Municipal Rapid Transit," read by Mr. Frank J. Sprague before the Institute, June 19th.[1] On account of the length of the paper it was considered wise to defer the discussion until this fall, and in considering the advisability of taking it up this evening the council decided that as we had a member in Richmond, who was on the spot and has taken great interest in the work to which Mr. Sprague referred in his paper, and who is in an entirely independent and unbiassed position, he would probably be able to give us some valuable information in regard to the work done. In addition to Mr. Leonard's contribution to the discussion, I have a note from Mr. Almon Robinson, of Lewiston, Maine,[1] in regard to gearing, which will also be read.

Mr. M. B. Leonard read his paper entitled "Some Objections to the Overhead Conductor for Electric Railways." (See page 520.)

The Chairman—Gentlemen, if it is agreeable to you, I will now ask the secretary to read Mr. Robinson's paper, as Mr. Robinson, I believe, is not here. Then, after the reading of the papers, the discussion will be open.

The secretary then read Mr. Robinson's paper, "Note on Gearing for Electric Railway Motors." (See page 522.)

Mr. Pope—I might say, in connection with this note of Mr. Robinson's, that he was present at the meeting at which Mr. Reckenzaun read his paper on "Electric Street Cars, with Special Reference to Methods of Gearing," September 20, 1887,[2] and he told me personally that he was much interested in the subject of frictional gearing, and he felt that it had got a black eye from Mr. Reckenzaun's paper.

The notices which were sent out announced probable contributions to the discussion by Mr. Mansfield and Mr. Blackwell. I have a letter of regret from Mr. Mansfield, announcing his inability to be present, and I am not certain that Mr. Blackwell is here this evening. There are no other papers.

The Chairman—Is Mr. Blackwell present, if so we shall be very happy to hear from him. (Mr. Blackwell was not present.)

The interesting paper of Mr. Leonard and the note of Mr. Robinson, seem to afford very good starting points for discussion, and the question is now open for any gentleman who wishes to speak. I see a number of gentlemen more or less intimately connected with electric street railways and electric power; we shall be glad to hear from any of them.

Mr. Ries, of Baltimore, is present with us this evening. Has he any remarks to make?

Mr. Elias E. Ries—Mr. President and Gentlemen:—It is not often that a paper upon so broad a topic contains so much solid information as the one that we are here to discuss. Mr. Sprague deserves to be congratulated upon the ability and thoroughness with which he has presented the subject, and I take pleasure in adding what little I can to the discussion of such of its features as seem to me to require more elucidation.

The paper may be divided into two parts; one dealing purely with the "Municipal Rapid Transit Problem" as determined by the conditions that obtain in New York city, and the other relating to the construction and operation of ordinary electric street railways. I shall take up the latter phase of the paper first, and then, if time permit, will have a few words to say on the general subject of rapid transit as applied to the requirements of New York city.

Mr. Sprague refers to several methods of converting the momentum of a train or car into useful current; one of these consisting in converting the propelling motor or motors of a train into braking generators when running on a down grade or coming to a stop, and returning the current generated back into the line for the purpose of assisting other motors. This method necessitates raising the counter E. M. F. of the motor until it exceeds the direct E. M. F. of the line, and as this latter is 400 or more volts, it will be apparent that only in a few exceptional cases is the train energy or momentum sufficient to develop in the motor or motors anything above the initial E. M. F., for any appreciable length of time. During all this period the energy of the train is simply being expended in overcoming the direct E. M. F., or, in other words, in preventing the entrance of the line current to the motor by developing the 400 or more volts necessary to oppose it; a result that can be as readily obtained without the expenditure of this energy by simply opening the motor circuit. The practical effect of the method referred to will be to partially brake the train, but except in a few extreme cases the line current derives no benefit or assistance therefrom. There is, however, another and more economical method of conserving the surplus energy of a railway train, which avoids the loss of the bulk of this energy and at the same time permits of the utilization of this energy *upon the train itself* at times when it is most required. This method, as developed by me some time ago, consists in the employment of a secondary battery so arranged as to be connected with the motor circuit whenever, as in stopping or descending a grade, the connection between the line and the motor is interrupted, and the latter is in condition to generate a current under the influence of the momentum of the train. The battery cells are connected in parallel or multiple series order during the time when they are in circuit with the generating or braking motor, so as to oppose an electromotive force of only a few volts to the charging current, thereby making the momentum of the train or car instantly available for changing the battery, this changing process continuing until the speed of the armature has been so reduced by its own braking action upon the train or car, that it is no longer capable of generating the few volts necessary to effect the entrance of its current to the storage battery. In this arrangement an automatic potential switch, of special construction, prevents the closing of the charging circuit until the E. M. F. of the current from the motor exceeds that of the battery, when it occurs almost instantly, and breaks the connection when the E. M. F. of the charging current falls below that of the battery, the entire arrangement being so simple as to require no attention whatever on the part of the motor man. The current thus reclaimed on descending grades and stops is, in the Ries system of electric railways, employed to assist in operating the train or car when ascending grades and when starting. The battery, or such portion of it as may be set aside for operating the motor or motors, is of course discharged at a higher voltage, and can be utilized for electric lighting and all other train purposes to which it may be applicable. It will thus be seen that a two-fold effect is obtained, since the surplus energy of the train, which under existing conditions is ordinarily wasted, is not only made to stop the train without the use of friction brakes, but the energy consumed in stopping the train is, with the exception of a very slight loss in conversion, etc., almost entirely recovered and turned to useful account. Mr. Sprague has stated, in referring to the operation of the New York elevated railway system, that 59 per cent. of the power expended by the locomotives on a round trip is used in starting, 24 per cent. in lifting, and only 17 per cent. in traction. That means that 83 per cent. of the total power expended upon the elevated railway system in this city is consumed on account of stoppages and grades, of which nothing is recovered, but on the other hand, the waste is augmented by the use of further steam to apply the brakes. If only one-half, or say 40 per cent. of this wasted energy can by the method above described be recovered, of which I have not the slightest doubt, the value of electric traction for roads of this character, over that at present used will be apparent, from this point of view alone.

Another matter of considerable importance is whether one or two motors are most advisable for street car work. I am myself in favor of employing but a single motor directly geared to both axles, and it is the universal opinion of electricians and engineers that in a case of this kind a single large unit is better than two or more smaller ones, and this is especially true in regard to street car motors. A great deal has been said about the difficulty of making satisfactory connection with both axles from a single driving source, but this can be overcome, and I may say I have devised a method of doing this which avoids most of the difficulties heretofore encountered. It is a question to my mind whether Mr. Sprague's assertion that independently driven axles necessarily give better track adhesion, can be sustained. In fact, it seems to me that the reverse is generally the case. There can be no doubt, as Mr. Sprague states, that independently driven axles will slip until they get the best grip, but it is also known that a slipping wheel or pair of wheels will readily continue doing so under the influence of the acquired impetus and the rotative strain exerted upon them by the motor. However, in ordinary street cars the load is constantly shifting from the forward to the rear axle, and vice-versa, due to the lurching of the car and unequal distribution of the weight or load. Therefore, supposing a car to be slightly overcrowded at its rear end, the forward wheels must necessarily slip, and the motor driving them will run light for the

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1. See the ELECTRICAL ENGINEER, August 1888, vol. vii., No. 80, page 340.

2. See *Electrician* and ELECTRICAL ENGINEER, vol. vi., No. 70, p. 395, October, 1887.

time being, leaving the rear motor, which was designed to do but half the total work, to do it all, and subjecting it to an enormous electrical and mechanical strain.

I have given this subject considerable attention, and have come to the conclusion that for street cars of ordinary construction the axles should *not* be independently driven, but should be directly connected with each other, preferably through the armature shaft of the motor itself, whose weight is equally borne by both axles. In this manner the combined tractive effect of all the wheels may be obtained in unison, which will reduce the tendency to slip, and the load upon and work done by the motor will be a constant quantity irrespective of the shifting of the load. For pivoted truck or eight-wheeled cars the objections to independent driving do not so seriously apply, but the advantages of a direct connection with both axles of a truck are even more apparent for other reasons.

I thoroughly agree with Mr. Sprague on the matter of making each car of an elevated train its own motor, provided the motors of the entire train are controlled from a single point. In all cases where stops are frequent this plan possesses numerous advantages, but for trunk line railways having substantial roadbeds a single large motor, or perhaps a front and rear motor suitably connected, but capable of independent operation when separated, will probably always be found preferable to a number of small ones.

One thing that struck me as very peculiar in connection with the Richmond road, was that an electrical engineer of Mr. Sprague's ability and experience should so utterly abandon all measure of precaution for the safety of his passengers and the public at large as would seem to be indicated by his employment of the track rails and ground as one side of the circuit, instead of using a double overhead conductor. This is the more to be wondered at when it is shown by Mr. Sprague's own description of the elaborate and extensive means employed for connecting the track rails and re-enforcing them by separate wires to insure perfect connection with one another and with the ground pipes, etc., that aside from its danger this plan is considerably more expensive than a second overhead wire and double trolleys would be. I can only explain this action on the part of Mr. Sprague by assuming that he has found the track return necessary to enable him to ascend the steep grades of the Richmond road, by reason of the increased tractive adhesion obtainable due to the passage of the propelling current from the wheels into the rails. If my memory serves me rightly, it was not very long ago—in his address before the American Street Railway Association at their Philadelphia convention last October,—that Mr. Sprague stated that on roads having grades of more than 6 per cent. he proposed to attach a hill horse to the motor car! Whether he intended this as a parting tribute to the usefulness of the patient and long-suffering car horse who has so faithfully served the public, I do not know; but at all events he stated that he did not believe it possible for a self-propelled car to get up the hill in any other way. This was some time after I had announced the results of some experiments I had made, both with the electric current and electro-magnetism, in which I was able to show and demonstrate that the tractive adhesion of driving wheels could be very largely increased by these means—sufficient, in fact, to enable a motor car to ascend a grade much steeper than any yet surmounted.

However, I might state here that this increased tractive adhesion can be obtained without subjecting the public at large to the danger incident to the use of a ground return. Every electrician knows, and perhaps no one better than Mr. Sprague himself, that a ground on any circuit multiplies the danger of leakage, and on an electric railway circuit carrying a pressure of 400 or 500 volts should never be permitted. In the Ries electric railway system we have a cheap and simple method of increasing the tractive adhesion without employing the track rails as a return, which can be applied to any electric railway operating on the parallel system. This consists simply in passing the current from the conduit or overhead conductors, after it leaves the motor, to the forward car axle, which, of course, is insulated from the car body, and to connect the rear axle, also preferably insulated, to the negative or return conductor. In this way the current, after passing through the motor, must traverse that portion of the track rails lying between the two pairs of wheels, which latter are thus included in the circuit. The portion of the track rails traversed by the current will not act as a ground, but simply as a good conductor inserted in the branch or loop that feeds the motor. This is only one of a number of ways in which an increased tractive adhesion may be obtained, but I prefer in most cases to employ a current that is entirely independent of the motive current and of such quality as to produce a very much greater and at the same time a variable tractive effect. I may say that we are at present engaged in applying this system to an ordinary steam locomotive, on a prominent railroad, and if the results obtained prove to be anywhere near what we have reason to expect from certain experiments made on a smaller scale, I shall hope to be able to show you a very decided increase in its pulling capacity, and to effect a considerable saving in the cost of operating the road.

With reference to the ideal method of braking referred to in the paper under discussion, I might state that a modification of our electro-magnetic traction apparatus has been applied by us for this purpose. In this we magnetize the car wheels as in our traction apparatus, but in addition provide an electro-magnetic braking arrangement, the whole being so arranged that when the brake circuit is closed, not only are the brakes applied to the tread of the wheels, but the co-efficient of friction between the wheels and the track rails is greatly and simultaneously increased, thereby enabling us to apply a greater brake-shoe pressure than now possible, and yet prevent the wheels from skidding upon the rails. This method of braking is effective in almost any weather, and is applicable to street cars or to railroad trains. In cases where braking is effected by utilizing the motor or motors as braking generators, as before explained, this system is still available and only the traction circuit needs to be established between the two axles of each truck to render it effective. This, in my opinion, constitutes the ideal method of braking, and before very long I hope to be able to show you such a system in practical operation.

Mr. J. M. Pendleton—I rise to make an inquiry. I have heard several eulogies on the Sprague motor that is used in Richmond, and I would like to inquire whether the motor used in Richmond has anything but a plain, series-wound Siemens armature? If it has not, it seems to be a very old form of motor—one that certainly has not got anything to give it a title except the maker's name. I think we ought to give to those who have invented certain forms, the credit of inventing those forms. A short time ago I looked over a work lately published by Mr. Silvanus P. Thompson—a very excellent text book, and one that must form a very valuable addition to any electrical library. In that work, replete with everything that an electrician would value, I found on one of the pages a very strong endorsement of the Immish motor—a motor that is well known in England, and one which it has been attempted to introduce in this country. To my surprise I found my own name and that of another inventor mentioned on that page as having invented a motor of a form discarded by Mr. Immish. Now, it struck me at the time that it was a misfortune that so valuable a book should contain anything to mar its high merit. A little motor intended for a very small use—a sixteenth of a horse-power—was not a fit subject for such a remark; and it naturally occurred to me to ask what is there in Mr. Immish's motor peculiar to Mr. Immish? It is certainly nothing but a Siemens armature in a two-pole field, and there was nothing indicative of the inventor about it, and the name of the motor certainly belonged only to the manufacturer. Now, in these motors we know that Mr. Sprague has spent a great deal of time and given a good deal of study to certain lines of regulation in motors, but they are certainly not adapted to car purposes, and if a plain series motor is put upon a car, why should we call it one thing or another? Therefore I think the inquiry is pertinent: Is there anything in the motor except that it is a series-wound motor, such as we have been familiar with a great many years, even before we knew the names of a great many manufacturers who certainly cannot claim the invention of a motor of that class?

Mr. C. O. Mailloux—It was at first my intention not to say anything in the discussion this evening, but I think it is my duty to speak disinterestedly of the matter brought forward by Mr. Pendleton. While it is true that there are very few types of motors existing, and that in fact the question of selecting a type, in the mind of an electrical engineer who is about to design a motor, comes down to but two forms, strictly speaking, yet it does not appear to me to follow that we should be compelled to give to the motor designed merely the name of that peculiar form. We have only to look into other fields of engineering—and I know no better example than this which he mentions—to see how the names go. If we were to give absolutely to Cæsar what is his, the engines that we use to-day would be known by the names of people who lived before we were born. As a matter of fact, while James Watt may have done a great deal for the steam engine, yet it does not follow that he is entitled to the full credit of the steam engine, because if we were to place the engine designed by James Watt in contrast with the engine designed later by Corliss, we would find great differences; and if you would come down still further and compare it with the triple expansion compound engines now being made, you would find still more marked differences. Yet, strictly speaking, they are all of the same type—a reciprocating piston taking steam at both ends, and the variations merely come in the form of valve motion and various other details. Now, the criticism made by Mr. Pendleton would imply that in designing a motor you have only to look at a book and find a picture that suits you the best, and then if you decide that it is to be a series motor or shunt motor, you simply go to work and have it made. Now, to us who have been through the mill—who "have been there," as the saying is—we know that the process is far from being as easy as that. We know that there are very intricate calculations to be gone through, and calculations that must be gone through in very adverse and trying situations, inasmuch as, so far from the art being entirely known, we are in fact only on the dawn of knowledge. In other words, the data that we have to work from, the facts, figures and principles, are very incomplete, and we must go often into the domain of the hypothetical to help ourselves out. Now, I think that so far from disparaging the efforts of people in designing, we should, on the other hand,

certainly give them credit for what they have done, because we ought to realize the amount of study, hard work, experimenting, and oftentimes expense, which has been necessary to enable them to arrive at those results.

I claim that if Mr. Sprague, or anybody else, is able, as an electrical engineer, to combine material and to mould it so that it shall accomplish results that nobody else has accomplished, then he is perfectly and fully entitled to have the motor known by his own name, just as much as a steam engine is known by the maker's name.

Mr. Pendleton—My friend, Mr. Mailloux, has not directly replied to my question. In the matter of preparing the work of others, where one has really become an inventor, has become a student in certain styles of regulation and has appropriated to himself other patents and other matters, he is entitled fully to the benefit of his work and to have it known as his work and his style of apparatus; but where he departs from that to another type, why should that name be continued when it is nothing of his work, and belongs to somebody else? That is the matter I spoke of. I did not intend to throw a bombshell into the controversy. It was a mere inquiry. I heard the motor lauded, and knowing the work of Mr. Sprague, his very intelligent, and you may say audacious, attempt to overcome the natural difficulties of a city having the grades of Richmond, I think he is entitled to the highest credit; but at the same time I thought that it might be well to distinguish what belonged to one and what to another.

The Chairman—I do not think there is any danger of Mr. Sprague's reputation for his distinguished service in the matter of street railways suffering any harm in a meeting of the Institute of Electrical Engineers; but I think we might better return now to the discussion of the subject of the evening—Mr. Sprague's paper, and the papers that we have had read in discussion of it here to-night.

Some interesting points were noted by Mr. Leonard, particularly in regard to what he considered the deficiencies of the overhead system and the relative merits of the storage battery. I hope Mr. Sprague will speak to us at this juncture.

Mr. F. J. Sprague—I am rather glad that some argument has come up in the discussion of the paper. I think possibly I am in a position to correct some of the impressions which have been received so as to remove doubts about certain points. I do not care to here enter into a discussion as to whether any work that I do shall go under my name or in some other man's. So far as the difference between the Sprague motor in Richmond and the Siemens machine is concerned, either Mr. Pendleton does not know what the Sprague motor in Richmond is, or what the Siemens motor is. We use in Richmond a double commutator machine which is unknown to-day to any one except those whom I have taught. Its plan of winding has never been published or described. It is, as I say, unknown except by the employés of my company, and if there is any question as to the similarity of that winding to some other, I have not the slightest objection to giving the necessary diagram of connections. It is a series machine, but a series machine which has some peculiar characteristics. It is wound with three sets of coils, and the peculiarity very largely consists in the method of connecting and certain switches, by which the coils in these machines are commutated and reversed, their field magnetization and their current varied at will, through progressive changes, by means of which, when desirable, we are enabled under various loads to maintain an almost absolutely constant field, while the current may vary 300 per cent. That has never been done with a motor before; that is, to so regulate the field that, with a variation of 300 per cent., a perfectly constant field will be maintained. This field connection is somewhat peculiar, so much so that it would be useless for me to attempt to describe it now, although I shall take occasion to publish a description of it in the near future. There are, however, some characteristics of motors other than the mere winding of the armatures or fields, or their regulation, which are essential for street car purposes. It is, as Mr. Mailloux says, a question partly of proportioning, partly of calculation, a putting together of those things which you have at hand to meet those conditions under which you have got to work. Two years ago, I think I may fairly say, such a problem as equipping the Richmond road, with its abnormal conditions, with the circumstances of manufacture which we had to meet, and in the time that was given to us in the then undeveloped state of this art, would have been looked upon as somewhat preposterous. I am frank to confess that had I known what I had to go through, I would, perhaps, have had neither the necessary courage, time or patience, or have cared to have risked the money which I did. I have spent in Richmond $150,000, and I have learned something. While I do not care to state all I learned, I have taken advantage of it in our future work. A great many of the principles of regulation that have been associated with my name are not characteristic of the Richmond machines. They are designed for other purposes. Now, referring to Mr. Leonard's paper, a great many of the deficiencies he speaks of exist in Richmond, and unless the machine were of superhuman design, they must exist there. A year ago those machines were put in in a great hurry. The maximum normal capacity that they ought to run at is about 7½ h. p. Very frequently they have been called upon to develop 10 or 11 h. p., an increase of about 50 per cent. In the nine months during which this road has been in actual operation, and it has run nearly half a million of miles and carried millions of passengers, not one working car has ever been inside of a closed shed. They have been housed in the street. The photograph which you have in the report of the paper read by me some months ago gives you some idea of where the cars have been kept. Of course, you are aware that when a machine is running it is exposed to more or less wear. It needs something of care and attention. A locomotive that makes two or three hundred miles is sent into a round-house, thoroughly cleaned and taken care of. It is a very good locomotive that will run with safety, and it is very poor management that will permit it to run more than three or four hundred miles without looking it over. The Richmond machines have run sometimes as high as 6,000 or 8,000 miles without being sent inside a covered shed. They have run without covers of any kind or character. They have run with six inches of water in the street and brake-beams running in the water, which was splashing on the motors. They have run until you could not tell what the machine was; until the accumulation of mud and oil and filth was of such a character that no other piece of machinery in the world would ever have run. I am not responsible, unfortunately, for the management of the Richmond railway. If so, we would not have the possibility of a number of cars lying in the car shed, so called, unfit for duty, after having been left in the streets during ten days of rain. The report from one of my own inspectors less than one week ago was that there was no more trouble in running a 40 car road by electricity than in one operating three or four cars. He is a level-headed, practical, cautious man, not given to strong statements, and very conservative in what he says or does. He says that out of 30 cars equipped for duty, there is no difficulty whatever in maintaining 29 on the road, if only that legitimate, ordinary, reasonable care is given to the machines which ought to be given to them; and that is the opinion of others who know the exact circumstances of the Richmond management, and the character of the attendance which the machines have had. There is no electric car in the world which has ever made anything like these records—from 80 to 110 miles a day on grades as high as 10 per cent., under loads 50 per cent. above the normal capacity of the machines in the hands of men oftentimes appointed for political purposes and not for intelligence, on duty 20 hours a day, and making 6,000 or 8,000 miles without going inside a shed to be cleaned off. I have been called a crank, and some time ago when I made the statement, as I did in the paper that was read here, that we would get to that position in electric motors in which it would be almost an impossibility in ordinary use to break them down, and that I proposed to wash the machines down occasionally, to get them clean, the remark was made: "Well, that fellow must be a damned fool." Well, I quietly pocketed that remark, and within the next thirty days or so we will have that machine out, and we will put one of those armatures that people have laughed about inside a barrel of water for 24 hours, and we will take it out and we will run it. There is no piece of electric machinery in existence to-day that will stand it. One of the difficulties which will occur on any road where cars are not properly and decently housed some part of the 24 hours is this: Cars that are running, of course, warm up, the pores open, they are ready for the absorption of any moisture. If it comes on a cold, damp, murky night, and these cars are left utterly unprotected, they will absorb more or less moisture. In dealing with the potential we are using there, of 400 to 450 volts on the line, you have a possibility of a short circuit in the coils. Some of the difficulties Mr. Leonard mentions, I think, he might have recognized as of a purely mechanical nature, or difficulties due very largely to lack of ordinary care. The breaking of a trolley wire, sometimes caused by a trolley catching in it, can be, of course, almost entirely obviated by one or two precautions; one of these is the non use of solder in the erection of a line. In putting up the Richmond line we used hard-drawn copper. Hard-drawn copper as it comes out of the mill has a remarkable tenacity, but when it has been handled, and when under the heat of a soldering iron it has been warmed up, you reduce it practically to the strength of soft-drawn copper; so that you will have at the point where solder has been applied a weak spot which entirely nullifies all your other precautions. In our future work, this trouble will be entirely removed, because we will not use solder from one end of the line to the other. The use of silicon-bronze or aluminum-bronze drawn for high conductivity and great tenacity, will likewise render less possible any accident due to the breaking of the wire. This wire can be drawn of from 100,000 to 150,000 pounds tensile strength to the square inch, and being put up without solder, I can see little possibility of that wire ever coming down.

So far as the use of poles is concerned, if you use a green pole, as the poles in Richmond were, it will bend; if improperly set in a clay soil, it will get out of position. If it is properly seasoned and set in concrete, there is no reason why it should give trouble. One of the most important roads that we have—we have some 26 or 27 now—is the West End road of Boston. Rights for an overhead system there having been granted within a few days, we are putting up a line that costs four times as much as the Richmond

line did per mile. I believe I said in my recent paper that the objection to overhead wires was entirely reasonable, because people did not put money enough into them. Having put all the money which I did in the Richmond road, I do not propose to put in any more there. On a new road, where I can make my own conditions before the contract is signed, I am willing to put in just as expensive a road as is desired. Instead of putting in wooden poles in Boston, we are putting in iron poles tested up to 1,400 pounds. Instead of setting them in clay, we set them in concrete. Those poles will not come down. So far as the span wires are concerned, there is no danger of their breaking.

As to the use of a single overhead line, that I know is a much discussed question. But I find the practice of most people is a single overhead line. There has been a good deal of "kicking" on the part of telephone companies. It has chiefly disappeared down in Richmond. The trouble is that the telephone companies had the earth and they wanted to keep it. (Laughter.) I can see no particular reason why a telephone company should not be required to exercise the same degree of care in putting up their lines that they would if the electric railroad were already in existence. The telephone man runs out his circuit as far as he can and charges as much as he can, and then, because some poor railroad company wants to put in some cheap and effective system of operating its cars, I do not think that it is quite just on the part of the telephone companies that they should raise their hands in such holy horror over the use of the earth circuits. Mr. McCluer, of Richmond, who was mentioned, had ingenuity enough to get out of his troubles. He took the trouble to run over his main telephone circuit, where they came near our wires, a single return wire, and he makes his telephone connections to that. His troubles have disappeared. I suppose it might have cost his system a few hundred dollars. If he objected to paying that, I suppose we could have paid it for him, but he has, as I say, overcome his troubles by the most trivial possible expense. If that is the only objection that telephone companies have got, it is not a legitimate objection. So far as the burning out of their exchange is concerned, I will have to correct Mr. Leonard in that. At the time one of their decayed poles fell down and landed three or four hundred wires on top of our lines, the dynamos were not running at all. This is the only pole breakage I know of. We have burned out some of their instruments, but that is simply because we took a reasonable amount of precaution, and they did not. They got their wires across ours, and they got the worst of it. The great trouble with telegraph and telephone business is this: the thousands of miles of dead wires hanging down in the streets and over the house-tops. A man who has a telephone does not take the trouble to take down his telephone wire after he has discontinued the service. There is no æsthetic sentiment in a telephone company. They are perfectly willing to say, "Here, you electric light people and you electric railway people are causing a great deal of trouble to our customers." If they would all join hands in an equitable arrangement, as some of them have, they would have little cause to complain.

A criticism has been made about the use of two machines on a car. I have spent half an hour trying to get the length of this room with one motor on a 6 per cent. grade, under a condition which happened to give a slimy surface on the rail, and I have seen under the same conditions, on a 10 per cent. grade, on a worse track, two motors handle the heaviest loads. It is not merely because the wheels can get a better grip—you have got your total weight available for traction. The forward wheels can also, in case of an emergency, travel faster than the rear wheels. That has been done, even on a level, and has the advantage of breaking up whatever obstructions there are on the track and leaving the track perfectly clear; if you put between your wheel a broom or brush, you have excellent traction. It could not be done by gearing both wheels to the same motor, simply because you could not get that independence of grip that is necessary. Running both pairs of axles requires certain devices, the use of which, in view of existing street car practice in the matter of constructing running gear, I do not think is advisable. There are some 40,000 or 50,000 cars in the United States, and there are one or two settled principles in them; one is, perfectly independent action of the axles. No four wheels on a car are of the same diameter; they are never cast absolutely alike; they do not run necessarily on the same tread. Any difference in the level of the streets will send the weight of a car down on one side. In fact, it seems to me, in the face of all I have seen, almost trivial to make any objection to the independent driving of two axles. I admit it is cheaper to build one machine to put on a car, but you can build two smaller machines of the same capacity. Space in a street car is a matter of considerable importance. You want to get large power on a car to handle heavy loads, but you have got to have it in comparatively small space.

As to keeping a trolley on a wire, I am quite willing to enter into a contract to put a trolley on a car which never can come off the wire, and, in fact, some of our cars are now running with one man, and have to run with one man, simply because the railroad people won't pay an additional conductor.

The methods of getting rid of troubles have been, of course, subjects of a great deal of study. It was not possible, a couple of years ago, to look forward and face all the conditions that arise in practice. We electricians did not know enough about street car practice, and street car men did not know enough about electric railways, so we had to join hands with the street car men, and we had to put the cars and motors into the hands of ignorant men and meet those difficulties in order to know how to get over them. I think I may safely say that the road we will put in sixty days from now will bear about as little resemblance in details to the Richmond road as it is possible for any two roads to bear to each other, simply because of great improvements, not only in the motors, but in the gearing, switches, trolley work and all overhead superstructure.

A two-wire system requires from two to four times the weight overhead. Where we put a main conductor alongside of the street and reduce the trolley wire to a single one a fifth of an inch in diameter, that enables us to keep our structure in position a great deal better. So far as safety is concerned, the fact that a horse was killed in Richmond in the early days of running, is no criterion of it. Two wires are more liable to come down than one; but you won't get killed with 400 or 500 volts. I have several times taken that potential myself. We don't know whether the horse that was killed in Richmond broke his neck or was killed by electricity. He was boiled in order to get his skeleton; he did have a broken neck; it is not known whether that killed him. We had a mule there. (Laughter.) A man threw a lump of ice down on to our wires. The first mule—two of them were being driven by a darkey—ran his head into the wire and kicked, and finally fell down and lay on the wire. About half an hour after that they telephoned up to the general manager's office and said: "We have got a mule pretty well used up by a current; we want damages." He said, "All right." About 48 hours afterwards they sent up word that they did not think they wanted any damages; that mule seemed to be a great deal livelier than before. (Laughter.) In the case of the horse, that was gross carelessness on the part of everybody concerned—the conductor who broke the wire, the dog who investigated it, and the boy who rode the horse; but the only one injured was the horse.

The statement that the Richmond company has never been able to run more than 30 cars out of 40 is an error. The Richmond road never expected to run more than 30 cars out of 40. Its plant was built for 30 cars. A 40 car motor equipment had nothing to do with their line work, or their central station work. It is perfectly possible, as a matter of fact, to run the entire 40 cars.

As far as the use of the storage battery is concerned, I am just as anxious as anybody else that the storage battery should be a success. But it will never get on a car in Richmond when they have got to put 4,000 pounds weight on that car. They never will take 20,000 pounds weight up a 10 per cent. grade with a storage battery until it is in a good deal higher state of efficiency than it is to-day. We have, although not prominently connected with storage battery work, been experimenting for a long time. We keep a car on tap. We have had built hundreds of plates in the past year, trying to devise some means of overcoming some difficulties that exist in storage batteries now. We hope to have a normal capacity of discharge in, say, a 35-pound cell of not less than 75 or 80 amperes, and that they can stand 150. The resistance ought to be about one-third or one-fourth of the present storage battery. The plates will be practically indestructible; and, finally, it won't be a Faure cell. That is the sort of thing I am looking for. I do not know whether we will get it. The results, so far, have been very encouraging, but we never will attempt to climb a 10 per cent. grade with it, and we never will put it on the market until we know it is satisfactory. We will do our own experimental work. We expect to get the battery down so that not more than 1,800 pounds is necessary to handle the car under ordinary conditions. That will be something of an advance. The credit will not be mine, except that I have to pay the bills. Two years ago it was not possible to design a street car motor for entirely perfect work. I do not think enough was known about street car work. Certainly we are in a position to-day to design a great deal better machines than we did then. I shall have the pleasure of showing and explaining to this association, in the near future, our two latest machines—one about 7½ h. p., the other about 15—and their construction, I think, will appeal to street car people at least. I think by the time the Boston road is running, which will be in about five or six weeks, if Providence is not against us in the matter of the weather, we shall be able to show such improvement to the overhead line, as to its efficiency, economy and appearance, the character of the motors and the work which they will do, as will be a subject for mutual congratulation.

Mr. L. F. Lyne -I came here to-night principally for the purpose of being instructed.

I would like to ask Mr. Sprague if he really meant that a locomotive only runs 150 miles before it needs repairs? I think he meant 1,000. There are reporters here, of course, and if they get that wrong it will not sound well. I understood Mr. Sprague to say 150 to 200 miles.

Mr. Sprague—I might as well correct that impression at once, if you will permit me. I said it was not practicable in locomotive

work to run over 200 to 400 miles without the locomotive going under shelter and being properly oiled and cleaned; I did not mean going into the repair shop. What I say about the Richmond machines is this: They are not put inside of four walls; they are simply left in the streets. You cannot leave a locomotive or any other machine in the street for eight months under all conditions of the weather and have a machine that will not be apt to sometimes give you trouble.

I was quoted a little while ago as making a remark about hill horses. I was asked by a man who was interested in storage batteries—I believe he lived in New Jersey—if I would recommend in the equipment of a road which ordinarily did not have more than two or three per cent grade, but which did have in some particular places a heavy grade of eight or nine per cent., the use of motors which would climb a nine per cent grade? I said that as a matter of commercial investment I would say no. I said: "You will find it cheaper if, when you get to that eight or nine per cent grade, you take the trouble to put on a horse." That, certainly, was the intention of my remark.

So far as Richmond is concerned, I did not expect, in the first place, that we were going to have a ten per cent. grade there. Our specifications are for eight per cent. We have in some places the equivalent of a thirteen per cent. grade. We develop a remarkable traction, a traction which I never anticipated would be gotten out of a car, but no matter how we magnetized our wheels there, unless we drove both axles we never would get up these grades at all times.

Mr. Lyne—There are one or two remarks made by Mr. Leonard that I would like to refer to. The devices, so far as I have been able to discover, in transmitting the power from the motor to the axle of the car, have been in many cases obsolete devices. For instance, the grooved friction wheel has been used on the "Ben Franklin" that was tried on the 9th avenue road. That device was abandoned by engineers years ago, because the friction wheel caused flat places. If a sufficient pressure was not brought to bear on these wheels to bring it up to the maximum point at once, the surfaces would slip on one another, and a flat place would result. When the Fontaine locomotive came out we were led to believe that the whole railroad system of the country would be revolutionized in a few months by that engine. A certain few men predicted its utter failure, and it failed, principally in consequence of the tires getting flat places on them. As soon as they did get a flat place, they began pounding themselves to pieces, and the result was a dismantling of the whole affair. We know that the same occurs in locomotives in climbing grades. They slip, get flat places, and then the tires have to be turned off.

I am glad Mr. Sprague is here to-night and that he has so fully explained the difficulties which have been shown to exist in an overhead line. I fully agree with him that an overhead line must be put up as if it was never coming down. It is an old principle in railroading that each train should have its own independent motor, or in other words, if you have a cable or a wire upon which each train depends for its propelling power, if that line fails or any detail fails, you stop your whole road. Now, we have either got to have the overhead line as a permanent structure like a bridge or a railroad structure, or else you have got to resort to some means like the storage battery to give each train its own independent motor. Then, if it fails, you can throw it on one side and the trains move on.

I want to say just a word in reference to the storage battery. Now, I do not pretend to know very much about electricity, but there are a few things I have found out in the last few years, during which I have been connected with the electric lighting business. While I do not believe fully in the storage battery as it is constructed at the present time, I do know that it has been misrepresented in a great many instances. I have been told that it does not give as great an efficiency as is represented. Now, we have just tested some storage batteries, and we have got 80 to 85 per cent. of the charge back, and the failure of some of the batteries (we put in two series in which the plates failed at the end of about three and a half months) was due to fault in the material. We put two other series in the same place with improvements that I had suggested from the experience we had had, which consisted in placing the plates, instead of one-eighth of an inch apart, five-sixteenths of an inch apart. Then the scales, when they formed, went directly to the bottom instead of lodging across the spaces between the plates and short-circuiting. Now, we have got two series of batteries with four vertical strips of hard rubber between each pair of plates. That has been in use now about four months. We have not had any of them short-circuited, and those are the series that we tested the other day and got 86 per cent. We have no trouble whatever from those batteries; but with the others in which we used the old rubber plugs and plates about one-eighth of an inch apart, the scales were formed the full size of the little square, and they would tip over and lodge across the two plates. We had to keep at work at them all the time picking out the scales. The batteries, with those improvements, give us satisfaction. There is one other improvement which has been suggested and which I think will be adopted. The scales fall to the bottom, and lodge across the wooden bridge or support upon which the plate rests. That can be overcome by simply having one series of plates with a leg at each end resting on the bottom of the cell and the other series of plates resting on a hard rubber support running through the other series of plates and resting on the top of the plates that rest on the bottom of the cell. That leaves the space entirely clear for the scales to fall to the bottom. I have great faith in the storage battery, and I believe that a storage battery will be made eventually which will give a good efficiency and be much lighter than those now made.

Mr. Sprague—The question of depreciation of line is a question of construction very largely. It is certainly not a question of wear. A consideration of the actual time in which a wire is in contact will show this. With cars that are making two minute headway and running seven miles an hour, with a round trolley wheel, making contact on a round wire, we have almost a line contact, but call it an eighth of an inch contact. Any portion of the wire is in actual contact with the wheel less than one-two-hundred-thousandth part of the time; in other words, in continuous current contact, not over one hour in 26 years. Consequently the current ought not to rapidly wear the wire out, and it does not. In fact, the period in which any particular part of the wire is in contact is not over one-two-thousandth part of a second when the car is moving seven miles per hour.

The question of insulation, leakage and lightning came up a little while ago. It is a remarkable fact that lightning does not necessarily always follow the single overhead wire. We have had in Richmond quite a number of cases of the line being struck by lightning. Our ground circuit is made by three paths; two through the boilers and water connections, and a third through by a covered wire running about 1,000 feet on poles out, and direct down, to the track. We have had lightning come over that wire several times, and the statement of the engineers is that it is about an even thing whether it comes in on that line or the other one. It terminates in a well, and as a matter of scientific interest the engineers sometimes watch it as it goes into this well. So far as the leakage is concerned on that line, it can easily be reduced to an average of one-tenth or one one-hundredth part of 1 per cent. It has never been sufficient to cause the slightest interference with the operation of the wire except in the case of the short circuit. If existing, it can very easily be perceived by taking the reading of the ampere meter. The leakage is nothing so far as loss of power is concerned.

Mr. D. E. Lain—About the only part of the matter that I care to go into now is the means of coupling the motor to the axle. In Mr. Sprague's excellent paper he compares the method of direct coupling with other methods, as coupling by means of chain gear, friction gear, etc., in a way which, I think, was rather hard on the direct coupling. I have had some experience with some of these methods, and it seemed to me, as far as I have seen, that the method of direct coupling offers certain advantages which no other method offers. The easy motion and perfect noiselessness of the direct coupling certainly place it ahead of any other means; the simpleness, of course, in this method is greater than in any other. All the details are reduced to a minimum. The objection, of course, is that on account of the slow speed which the armature must necessarily make, running no faster than a driver, a larger machine is necessary. This may be an objection, and may not. In street railway work, where certainly not more than 10 h. p. is needed, where the whole equipment should not weigh more than say 5,000 pounds, when the car is loaded, the weight of the motor enters as such a part of the whole weight with the weight of a direct coupled motor, that it is not of such great importance after all. If the drivers be reduced to say 18 inches or thereabouts, a motor can be built that is not necessarily over 25 per cent. greater in weight than one using gear. This difference, this small difference, is offset by the greater efficiency of direct coupling over the gear. Of course, gear transmission is not possible where speed is reduced or changed from say 1 to 12 or 1 to 10 without some considerable loss of power. All this is saved in the direct connection where the loss by transmission should not be more than a very few per cent. So, of course, while we must all pardon Mr. Sprague for claiming that his particular system is better than any other, we are all willing to concede that this is due to the necessary qualities which go to make up a successful inventor, and also to the greater knowledge that Mr. Sprague has of his system than of any other; yet I think before the close of a year, at least before the close of next year, results will be obtained with direct coupling that will show it is possible to use a direct coupled motor even for so small work as street cars, that is quite as efficient, taking it all the way through, taking the total efficiency of the system, as gearing.

Mr. Leonard—With reference to the statement in my paper regarding the burning out of the telephone exchange, that statement was based on information I received from the telephone manager's office yesterday afternoon.

In regard to the difficulty and trouble experienced by the telephone exchange people, on account of the ground circuit of the electric railway, it has been largely, if not altogether remedied, by the erection of a metallic circuit, or what amounts to the same thing; running out a large copper wire to which the telephone wires are grounded instead of going to a gas pipe as

ordinarily. The difficulty has been obviated in that way; but there are quite a number of private telephone lines put up by various people, including our railway company, which cannot afford to go to the expense of putting up metallic circuits, and the result has been that we have been obliged to discard our private telephone line and pay tribute to the telephone company and their metallic circuit system.

With respect to the mechanical difficulties which Mr. Sprague alluded to, and which, of course, have been improved upon since the road was first erected, it is true that those mechanical difficulties can be considered as temporary and not inherent; but the electric road at Richmond was put forward as being a sample, I may say, of what has been accomplished, and of course we could only take what was actually being done, and criticised it accordingly. This I endeavored to do in the few remarks I made. That the work is susceptible of improvement is, of course, at once apparent to almost everyone; and that Mr. Sprague has in other cities succeeded in improving on the overhead system is nothing more than what would be expected from the ingenuity and skillfulness with which he has overcome the difficulties that were encountered in the Richmond enterprise.

Mr. Thomas Whiteside Rae (called upon by the chairman)—There is nothing that I have to say in addition to the remarks that have been given to-night, and I would like to record my hearty concurrence with Mr. Sprague's dictum respecting overhead lines. It is simply, as with most engineering questions, a financial rather than a technical one. One may have a good, durable, sightly overhead line by simply paying sufficient money for it. As at present constructed they do develop obstacles of various kinds and certainly are not as symmetrical as they might be, and do lack the perfection that might be given by the expenditure of more money. This question arises, though it is quite possible, I think, to make use of an underground conduit at perhaps no greater expense (certainly no greater when one considers the cost of maintenance of a properly built conduit), than a properly built overhead system would entail, and the difficulties which Mr. Leonard referred to, I think, cannot fail to be recognized by everybody; but that they are essentially inherent to the system does not necessarily follow, as Mr. Sprague has pointed out very clearly. The question is a financial one rather than a technical one.

Mr. Sprague—I think we will know much more about it when we have gone through a Northern winter which we shall do very soon. We have track-cleaning cars, and we shall put ample power behind them and can do the work of cleaning much faster than with horses because we have the power behind us rather than ahead of us.

Dr. S. S. Wheeler—Mr. Sprague in speaking of the liability of the wire to wear from the electricity mentioned the fact that it could not possibly wear because it was only in contact at one point at a very small part of the time—about a thousandth of the time. I should think that the fact of wear would be due to a very minute jump that the electricity would have to make when the roller hops a little off the wire. In fact, when he said that the roller was only in contact with any particular part of the wire about a thousandth of the time I thought he only referred to the danger of it hopping off.

Mr. Sprague—It was not that to which I referred. It is not the same as a sliding contact on the wire. Your wheel is turning all the while and there is no difference of potential between the part you leave and the part you are going on. You have a good contact where the trolley is held up by a good spring; you may inspect that wire by a microscope and detect very little signs of wear at all. There would be a very slight frictional wear, and it is probable there is a certain percentage of slip of these trolley wheels on the wire. I have, after eight months wear on the very heaviest portion of the line, very carefully inspected the wire, which was chemically cleaned, and I was agreeably surprised to see the small evidence of depreciation. If there is no sparking then the wear is entirely due to friction. The fact is the wear is remarkably light.

The Chairman—We would be very glad to hear from some member of the society, which has been our host here so long and allowed us to use its rooms. I believe Mr. Emery, of the Society of Civil Engineers, is present. He may have something to say to us.

Mr. Charles E. Emery (of the Society of Civil Engineers)—Gentlemen: This is a complete surprise. I came here to learn, because I know nothing of the subject; but I certainly am very much edified and I congratulate you, not only on the advance in electrical science, but on the advance you have made in organizing a society in which you can all join in the discussion of subjects which are so interesting to you and to us all, and I trust that you will grow to be one of the strongest and best societies in the country. Thanking you for the attention of calling on us I will ask to be excused.

Mr. Sprague—I would like to make one remark in regard to lightning. We had the line struck by lightning several times, and we have had motors on cars burnt out, but I believe I may safely say now that we have got lightning pretty well harnessed. I believe now there is no difficulty whatsoever in absolutely and perfectly guarding a car or a central station, so that lightning simply cannot get to the machine. We had three darkies sitting on the back dashboard of a car; one of them was sitting on the switch. The lightning came in, and grounded through the switch. Those three darkies jumped off the car at a very lively pace, but there was no danger. We have had the lightning come in and ground through the switch at the time the motor men were running the car. They paid not the slightest attention to it. They simply heard the click—that was the end of it. It will now be perfectly guarded against. It cannot get into our machines, and it cannot get into our stations; at least if it does it is only one time in 10,000, and then it goes to earth harmlessly.

Mr. T. Commerford Martin, chairman of the committee on papers and meetings, made the following announcement—The next meeting will be held on November 13th. The papers are as follows:—Professor W. E. Geyer, of the Stevens Institute, will read a paper on "A New Motor for Direct and Alternating Currents." We have with us this evening a gentleman whose acquaintance I think you will be glad to make. He is one of the leading electricians and mathematicians of France; he is also well known as one of the leading contributors to the leading electrical paper in France, *La Lumière Electrique*, Mr. Abdank Abakanowicz. I am very glad to announce that on the same evening, November 13, that gentleman will favor us with two papers, both of which will be accompanied by experiments and demonstrations; one will be on the Carpentier electrical method of recording and reproducing music; the other will be on the Abdank magnetic coil.

Adjournment.

ANNUAL REPORT

OF THE

PRESIDENT OF THE WESTERN UNION TELEGRAPH COMPANY.

FOR THE YEAR ENDED June 30, 1888.

CAPITAL STOCK.

The capital stock of the company outstanding is $86,199,852.06, of which $25,976.70 belongs to and is in the treasury of the company. It was increased during the year to the extent of $5,000,000 for the special purpose of acquiring the Baltimore and Ohio Telegraph Co. A small portion of it is still represented by certificates of indebtedness, for which capital stock certificates have not yet been issued.

BONDED DEBT.

The bonded debt at the close of the year was as follows:—

Bonds due March 1, 1900, 6 per cent	$871,398.00
Bonds due May 1, 1900, 7 per cent	4,920,000.00
Bonds due May 1, 1902, 7 per cent	1,325,000.00
	$7,116,398.00
Less balance of sinking funds appropriations not yet used for redemption of bonds	379,359.68
	$6,737,038.32

During the year Sterling bonds due March 1, 1900, to the amount of £4,100, and building bonds due May 1, 1902, to the amount of $11,000, were redemed by the sinking fund trustees.

BUSINESS OF THE YEAR.

Surplus, July 1, 1887		$7,002 185.11
The revenues, expenses and profits of the year ended June 30, 1888, were as follows:—		
Revenues	$19,711,164.12	
Expenses	14,640,592.18	
Profits		5,070,571.94
		$12,072,757.05
From which there was applied:—		
For dividends	$4,043,949.81	
" interest on bonds	490,258.30	
" sinking fund appropriations	40,000.00	
		4,574,208.11
Deducting which, leaves surplus, June 30, 1888, of		$7,498,548.94

The expenses for the year were:—	
For operating and general expenses	$10,065,843.27
" rentals of leased lines	1,942,485.80
" maintenance and reconstruction of lines	2,085,126.54
" taxes	355,877.74
" equipment of offices and wires	241,258.83
Total expenses as above	$14,640,592.18

RECAPITULATION.

The net profits for the year were		$5,070,571.94
Out of which there was paid:—		
For interest and sinking funds	$530,258.30	
Four quarterly dividends, aggregating	4,043,949.81	
And added to the surplus invested in new property	496,363.83	
Making		5,070,571.94
The increase in gross revenues over the previous year was		$2,519,254.17
In expenditures		1,485,923.64
And in net earnings		1,033,330.53

The maintenance and operation of 14,561 miles of additional line, with 91,607 miles of additional wire, and 1,583 additional offices, requiring 2,821 additional employés, and the transmission of 4,069,425 additional messages, made an increase of expenditure inevitable; but added to the necessary increase of maintenance and operation, there was the total expense of the Baltimore and Ohio system for some months, with the additional cost of buying off onerous contracts for leases of useless offices, and for other privileges and services which could not be utilized, the continued reconstruction of trans-continental lines, and the extraordinary expense of rebuilding and repairs consequent upon the memorable blizzard of last March.

CONSTRUCTION AND ACQUISITIONS.

In addition to the acquisition of the Baltimore and Ohio Telegraph system, consisting of 6,711 miles of lines, carrying 54,087 miles of wire, for which $5,000,000 were paid in the capital stock of the company at par; and of the New York and Southern Telegraph system of 1,528 miles of lines, and 5,090 miles of wire, there was constructed directly by the company and paid for out of the treasury 6,322 miles of line and 32,430 miles of wire, on which account there was appropriated $1,219,590.67 in cash.

There was also taken and paid for in cash $400,000 of additional stock in the Metropolitan Telegraph and Telephone Co. at par.

The total additions to the plant were 14,561 miles of lines and 91,607 miles of wire, and 1,583 additional and newly equipped offices. The acquisitions during the year in mileage of lines and wire and number of offices are about twice as great as the entire plant of any competing system the company ever had, and greater in mileage of wire than the entire system of this company after its consolidation with the American and United States Telegraph companies in 1866.

The average rate received per message during the year was 31¼ cents, as against 30⅜ cents for the previous year; and the average cost to the company of handling its messages was a fraction greater than the previous year, 23¼ cents, per message. The increase of less than one cent in the average rate collected is due partially to the advance of the 10 and 15 cent rates for short distance messages, but more largely to the greater percentage of increase in the long-distance messages, on which the rates have been reduced. In ascertaining these average rates it is necessary to eliminate from the gross revenues all that has not been received for the transmission of messages, and from the expenses all that does not pertain to such transmission.

GENERAL STATEMENT.

The following exhibit shows the revenues and disbursements of the company for 22 years from July 1, 1866:—

Surplus of income acc', July 1, 1866..	$275,357.24	
Net revenues for 22 years, from July 1, 1866, to June 30, 1888	91,108,369.59	
Making an aggregate, June 30, 1888, of		$91,383,726.83

During this period there was applied:—

For cash dividends	$51,185,565.07	
For scrip dividend	1,199,852.06	
For cost of 59,606½ shares of Western Union Telegraph stock, purchased and owned by the company, which was distributed to stockholders in 1879	3,302,198.90	
For cost of 72,010 shares of Atlantic and Pacific Telegraph stock, purchased and owned by the company, the proceeds of which, in Western Union stock, were distributed to stockholders in 1881	1,806,250.00	
For interest paid on company's bonds	9,173,597.19	
For cost of 396⅓ shares of Western Union stock, purchased and owned by the company, which were canceled to make the capital stock, after the issue of the new stock in 1881, exactly $80,000,000	26,836.00	
For amount reserved for interest on bonds and for sinking funds, accrued to June 30, but then not yet due and payable	106,086.64	$66,800,385.86
Leaving a surplus of		$24,583,340.97

Which is represented as follows:—

Construction of new lines, erection of additional wires, patents, etc., prior to October 1, 1881	$9,540,977.55	
Purchase of telegraph lines and of the stocks of companies leased by the Western Union Co. (upon which interest or dividends are paid as rental) prior to October 1, 1881	2,448,182.66	
Gold and Stock Telegraph Co.'s stock (18,905 shares)	1,176,009.00	
International Ocean Telegraph Co.'s stock (15,170 shares)	961,606.42	
Brooks' Underground Telegraph Co.'s stock (1,000 shares)	95,000.00	
Southern Bell Telephone and Telegraph Co.'s stock (1,687 shares)	84,825.00	
Sundry other stocks and bonds	88,157.33	
Western Union bonds redeemed and canceled	1,488,588.40	
Sinking fund (portion not yet used for redemption of bonds, exclusive of interest allowed by trustees)	311,917.69	
Broadway and Dey street building ... $2,365,689.52; Less amount provided from the proceeds of bonds issued ... 1,802,202.00	563,487.52	
Real estate, other than above	144,300.38	
Supplies and material on hand unissued	182,290.06	
Surplus, June 30, 1888	7,498,548.94	
		$24,583,340.97
On account of these assets, a stock distribution was made in 1881 to the amount of		15,526,590.00
Deducting which leaves a balance of.		$9,056,750.97

The above balance of $9,056,751, is the aggregate surplus not represented by any form of capitalization, and which has chiefly been invested in construction and new properties. The difference between this balance and that which is shown in the statement of "business for the year" is because of appropriations for construction out of earnings previous to October 1, 1881, over and above the $15,526,590 capitalized by the issue of capital stock in 1881, and which, previous to October of that year, had been carried into the quarterly statements. Since that period, in compliance with a resolution of the board of directors, a separate account of construction and purchase of new properties has been kept, which, as shown in the last previous report, has been credited with $1,000,000 received from the sale of bonds; with $143,976.87 from the sale of telephone properties; and with $1,199,852.06 capitalized by the issue of scrip dividend since converted into stock—all of which were applied as a credit to this account.

Of the $51,185,565.07, which has been paid to stockholders in cash dividends since July 1866, $30,051,632.73 have been paid since the consolidation with the American Union and Atlantic and Pacific companies in January, 1881, and in addition thereto $12,198,823.83 have been advanced and paid within the same period for new and additional properties, on account of which, however, $1,143,976.87 has been derived, as before stated, and the remainder advanced and paid in cash out of the treasury of the company. A fraction less than $1,200,000 was capitalized by the issue of the scrip dividend, and credited to this account.

STATISTICS.

The following table exhibits the mileage of lines operated, number of offices, number of messages sent, receipts, expenses, profits and average tolls and costs per message for each year since 1866.

Year	Miles of poles and cables.	Miles of wire.	Offices.	Messages.	Receipts.	Expenses.	Profits.	Average tolls per message.	Average cost to company of message.
1866	37,380	75,686	2,250	....	$	$	$		
1867	46,270	85,291	2,565	5,879,282	6,568,925.36	3,944,005.63	2,624,919.73	.....	....
1868	50,183	97,594	3,219	6,404,595	7,004,560.19	4,362,849.32	2,641,710.87	104.7	63.4
1869	52,099	104,584	3,607	7,934,933	7,316,918.30	4,568,116.85	2,748,801.45	89.3	54.2
1870	54,109	112,191	3,972	9,157,646	7,138,737.96	4,910,772.42	2,227,965.54	75.5	51.2
1871	56,032	121,151	4,606	10,646,077	7,637,448.85	5,104,787.19	2,532,661.66	69.5	45.7
1872	62,033	137,190	5,237	12,444,499	8,457,095.77	5,666,863.16	2,790,232.61	66.2	43.8
1873	65,757	154,472	5,740	14,456,832	9,333,018.51	6,575,055.82	2,757,962.69	62.5	43.4
1874	71,585	175,735	6,188	16,329,256	9,262,653.98	6,755,733.83	2,506,920.15	54.9	39.5
1875	72,833	179,496	6,565	17,153,710	9,564,574.60	6,335,414 77	3,229,157.83	54.	35.2
1876	73,532	183,832	7,072	18,729,567	10,034,983.66	6,635,473.69	3,399,509.97	50.9	33.5
1877	76,955	194,323	7,500	21,158,941	9,812,352.61	6,672,224.94	3,140,127.67	43.6	29.8
1878	81,002	206,202	8,014	23,918,894	9,861,355.23	6,309,812.53	3,551,542.70	38.9	25.
1879	82,987	211,566	8,534	25,070,106	10,960,640.46	6,160,200.37	4,800,440.09	38.6	25.2
1880	85,645	233,534	9,077	29,215,509	12,782,894.53	6,948,956.74	5,833,937.79	38.5	25.4
1881	110,340	327,171	10,737	32,500,000	14,393,543.85	8,485,264.13	5,908,279.72	38.4	25.6
1882	131,060	374,368	12,068	38,842,247	17,114,165.92	9,996,095.92	7,118,070.00	38.2	25.8
1883	144,294	432,726	12,917	41,181,177	19,454,902.98	11,794,553.40	7,660,349.58	38.	26.
1884	145,037	450,571	13,761	42,076,226	19,632,939.60	13,022,503.90	6,610,435.70	36.5	25.2
1885	147,500	462,283	14,184	42,096,583	17,706,833.71	12,005,909.58	5,700,924.13	32.1	24.9
1886	151,832	489,607	15,142	43,289,807	16,298,638.55	12,378,783.42	3,919,855.13	31.8	23.4
1887	156,814	524,641	15,658	47,394,530	17,191,909.95	13,154,628.54	4,037,281.41	30.4	23.
1888	171,375	616,248	17,241	51,463,955	19,711,164.12	14,640,592.18	5,070,571.94	31.2	23.2

The foregoing table exhibits the growth and increase of the property and business of the company year by year for 22 years. The additions to the property have already been stated. The traffic shows an increase of over 4,000,000 messages handled, and of 20 per cent. in the revenues derived from the hire of leased wires mainly to the press and to business houses, the messages over which are not taken into the count The increase in gross revenues was over 2,500,000, and over 1,000,000 in net profits, as compared with the business of the previous year.

Attention is called to the last two columns of the table, showing the steady reduction in rates of tolls and in the cost of the service for 20 years. It will be seen that the public are enjoying a superior service at less than half the average rate of tolls that it cost the company to perform the service 20 years ago.

PRESS SERVICE.

The service for the press, and the aggregate revenues therefrom, continue to bear about the same proportion to the general traffic in the transmission of messages, although there was an increase of 50 per cent. in the amount received for the lease of wires to the various press associations and individual papers now aggregating over 12,500 miles of wire leased exclusively for press reports. On these wires they employ their own operators, and the reports transmitted do not enter into the accounts of the company, yet the associated press service handled by the company shows a small increase in the number of words transmitted, whilst the special press service (being reports sent to a single newspaper), shows an increase of 32 per cent.; and the total revenues for account of press service, including the rental of leased wires, show an increase of 28 per cent. over the previous year.

The table appended exhibits the assets in the treasury, the only material changes from last year being the addition of 4,000 shares of the capital stock of the Metropolitan Telegraph and Telephone Co., and the addition of $150,000 each in the capital stocks of the American District Telegraph companies of Baltimore and of New York.

The ensuing year, of which the results of the first quarter are approximately known, promises a greater increase of traffic than ever before realized, and the outlay for new property is not likely to be nearly so great. Respectfully submitted,

NORVIN GREEN, *President*.

THE NEW YORK BOARD OF ELECTRICAL CONTROL.

The meeting of the Board of Electrical Control, on the 17th inst., was chiefly remarkable for the exhibition of the determination of the board to expedite the satisfactory solution of the subway question, not only by the active measures that have lately been carried out, but by inviting the participation of the electrical companies in a discussion of the situation.

A letter addressed by the commissioners to the United States Illuminating Co., the Brush Electric Co., the East River Electric Light Co., the Harlem Lighting Co., the American Electric Manufacturing Co., the Mount Morris Electric Light Co., the North New York Lighting Co., the Ball Electric Illuminating Co., and the Daft Electric Power Co., invited those companies to attend a meeting of the board on Friday, the 19th inst., for the consideration of the subway question. The letter refers to the opposition which has been met with on the part of corporations engaged in the electric lighting business to the burial of their wires, and the lack of co-operation which has characterized the position assumed by certain officials, and goes on to show that under existing conditions it is impossible for the board to carry on its work in the manner that it evidently intends. Reconstruction is insisted on, and it is stated that the rules and regulations drawn up by Dr. Wheeler will be submitted to the attention of the meeting on Friday, 9th. "It is the opinion of the committee appointed to report on the matter, and the board, that under proper regulations the use of electric conductors for high tension currents can be made reasonably safe, and it is believed that the welfare of the corporations demands this co-operation." The letter indicates the possibility of considerable concessions being made to the electric lighting companies, but at the same time it is not difficult to trace the hand of iron under the glove of velvet.

Dr. Wheeler's report showed that 283 notices of violations of the rules and regulations of the board had been sent to the Bureau of Incumbrances. Of these 183 related to dead wires, none of which had been acted upon. One hundred related to dead poles, of which 40 had been acted upon, 60 remaining unattended to. The latter comprise all the notices but 13 of dead poles and dead wires belonging to the United States Illuminating Co., and about 33 miscellaneous notices. No dead wires have been removed by the Bureau of Incumbrances, excepting in the few cases to clear lines and poles which were to be taken down, the superintendent of the bureau stating that he has no force of men with which to do this work. The work of removing the dead poles has been carried on continuously from the time it was started until Oct. 15. The forty notices which have been acted upon by the Department of Public Works have entailed the removal of 312 dead poles and 404,183 feet of dead wire. There have been 214 new notices of violations of rules and regulations since the last meeting of the board. Dr. Wheeler also gave a full list of the lines of wires, in accordance with the direction of the board.

A letter from Mr. W. H. Eckert, general manager of the Metropolitan Telephone Co., reported very satisfactory progress in the removal of wires, and Commissioner Gibbens commended the way in which the company were pushing the work, and stated that they had removed 15,000 miles of wire at a considerable cost. They had spent in the lower part of the city $1,000,000 to get everything in good form.

Secretary Moss reported that the wires in Second avenue between Sixty-fourth and One Hundred and Twentieth streets have been removed, and that Sixth avenue is clear of poles from Twenty-first to Forty-eighth street.

The Western Union Co. stated that arrangements to remove the wires in Broadway between Fourteenth and Thirty-fourth streets are being made with a view to their being placed underground. The telephone company is preparing to bury the wires in this section.

The bad condition of the conduits in Park Row and lower Broadway was discussed, and a report submitted showing that, owing to leaks from the New York Steam Heating Co.'s pipes the temperature in the conduit man-holes at some points is as high as 209 degrees. The Western Union Co. reported its cables as so injured as to necessitate their replacement, and ask permission to distribute five 50-conductor overhead cables from the main office to the branches.

Chief Engineer Beckwith, of the Construction Company, stated that the work on the subways would probably be continued until Dec. 1, the same as last year. Up to the present time about 40 miles of trench have been dug, 500 miles of single ducts have been laid, and 550 man-holes have been constructed.

The business of the board is just now so urgent that until further notice the commissioners will meet Tuesdays and Fridays at 12 o'clock.

A special meeting of the board was held at the office of the board on Friday, the 19th inst., at 11 o'clock.

Further time was given for the report of the engineer and expert on the question of overcoming the difficulty of the steam pipes, in order that additional investigations could be made. The rules and regulations which have been prepared by Dr. Wheeler were submitted, and eventually adopted as far as rule 29, when their consideration was postponed in order to allow Mr. E. Lauterbach to read a letter from the chief engineer of the Construction company, giving temperature tests on lower Broadway. These showed that the majority of the man-holes had a temperature of 80 to 100 degrees, notably at Park Row, Cedar street and Exchange place. The experiments that had been carried out showed conclusively that the heat was not caused by radiation, but by the leakage of the steam pipes. The company had shown the greatest willingness to meet the necessity for repairs; but it was a question whether any preventive known to science would actually overcome the difficulty. This raised the question whether a private corporation like the Steam Heating Co. should be allowed to use the streets in any way which would interfere with the convenience and comfort of the public.

Mr. Andrews, the president of the Steam Heating Co., said that the company had constructed this plant with the best materials that could be got, and had instructed their engineers to put in the best work that could be done. The usual factor of safety was five to one, but they had doubled this and made it 10 to one. They run their steam at a pressure of 85 pounds through pipes that could stand a pressure of 1,000 pounds, so the fault could not lie in any general weakness or ineffectiveness. The fault was due to one single blunder of their engineer, in using wooden wedges for holding the pipes together, instead of cast-iron wedges. The wooden wedges shrank with heat and age, and left the joints of the pipes open. To put in iron wedges on the two miles of pipes originally would have cost $100, but in repairing or substituting they had already spent $250,000. That this was the sole cause of the difficulty was proved by the fact that their pipes uptown, *i. e.*, in 58th street, which are put together with iron wedges, have never shown a particle of leakage. After this somewhat startling admission, on motion of Commissioner Gibbens, it was resolved to defer further consideration of the subject until the expert and engineer of the board had been heard from.

Commissioner Gibbens, as a committee to consider the petitions of the Manhattan Electric Light Co. and the Safety Electric Power Co. for the privilege of running wires and doing electrical business in New York, said that the papers seemed to be in due form, and, on motion, the petitions were granted.

A communication was then read from the Bureau of Incumbrances, enclosing a letter of the United States company, which stated that certain enumerated poles and wires were not dead, as reported to the board, and Superintendent Richardson asked to have them verified. The report of the expert was read, stating that they had been re-inspected and all found to be dead, excepting one or two cases where the poles or dead wires had been put into use recently by putting up the connections with new pieces of wire, and so connecting the fixtures complained of on to line

circuits. The secretary of the board was directed to write to Mr. Richardson stating these facts, and repeating that the wires and fixtures were all dead, according to the meaning of the law, those that are now alive having been connected recently.

An application presented from the United States company for permits to connect a number of lamps, etc., was granted. A permit was also applied for by the same company to make numerous repairs, to which the secretary was directed to reply that according to the rules and regulations of the board, permits for repairs were not needed, except in the condemned district, where permits will not be granted.

A permit was granted to the East River company to run wires on 6th avenue and 18th and 38th streets. The meeting then adjourned.

At the meeting of the board on October 30, a number of permits were granted to connect lamps with existing circuits. The mayor referred to the board a letter from John A. Gano in relation to safety cut-outs, which was referred to the expert of the board. The request of the Western Union Telegraph Co. for permission to string five cables on poles was laid over until Friday next. The Western Union Telegraph Co. allege that the extreme heat in the subways destroys their cables. The telephone company also claim that their wires are badly damaged by the heat.

POINTERS.

.... I HAVE often been asked the question whether alternating dynamos can be worked in parallel. They can, when they are fully loaded, down almost to half load, but below that they do not synchronize.—*Professor George Forbes.*

.... FIRE, water, earth, and air have long been his slaves, but it is only within the last few years that man has won the battle lost by the giants of old, has snatched the thunderbolt from Jove himself and enslaved the all-pervading ether.—*G. F. Fitzgerald.*

.... ALL attempts to revive the Franklinian, or material theory of electricity, have to be so loaded with assumptions, and so weighted with contradictions, that they completely fail to remove electricity from the region of the mysterious.—*W. H. Preece.*

.... TO make important progress, it is necessary to leave the beaten track traveled over again and again by the scientific schools, and to seek some elevated standpoint from the outside where we can look down upon matter and its associated forces as a whole.—*S. Alfred Varley.*

.... THE extreme flexibility and capacity for self-regulation possessed by any properly organized system of alternate current generation, distribution and re-conversion, renders the alternating current peculiarly applicable to the varied requirements of electric railway transit, and will beyond doubt contribute materially to an early introduction and subsequent extension of this as yet untried system of electric railway operation.—*Elias E. Ries.*

.... ALTHOUGH it is a sad confession to have to make, that the very best of our steam engines only utilizes about one-sixth of the work which resides (if the term may be used) in the fuel that is consumed, it is, nevertheless, a satisfaction to know that great economical progress has been made, and that the 6 or 7 pounds of fuel per horse-power hour consumed by the very best engines of Watt's days, when working with the aid of condensation, is now brought down to about one-fourth of this consumption.—*Sir Frederick Bramwell.*

MISCELLANEOUS ITEMS.

The *New York Herald*, of the 11th, contained the details of a plan—said to have originated with five Western Union operators—for tapping the wires leading to the Jerome Park race course, and so securing the results of the races in advance. Although the details were said to have been carefully worked out and the apparatus in position, the scheme failed on account of a too sensitive conscience on the part of one of the plotters. The Western Union officials deny the truth of the story.

There is very little of interest to electricians at the American Institute fair, the fifty-seventh opening of which took place on October 3d. Mayor Hewitt delivered one of his characteristic addresses on the occasion.

On October 5th, at the trial of the long drawn out Snow-Alley case, a verdict was found in favor of Snow, at the town of Dedham, Mass. Judge Blodgett presided, and the depositions of Lester A. Bartlett, Thomas Wallace, Elisha Gray, and others, were read; and George L. Shorey, and Hon. Alanson W. Beard, appeared as witnesses. Mr. Beard, as president of the Postal Telegraph Co., testified as to what he knew of Mr. Snow's former relations with Mr. Alley. Mr. Snow testified in rebuttal. The case was then given to the jury and a verdict rendered. Exceptions were taken, however, and as far as is known, the case is still on its travels through the courts.

The electrical committee of Philadelphia city councils have agreed to report for passage the ordinances authorizing the American Telegraph and Telephone Co. to lay conduits on the west side of Fifty-second street to Lancaster avenue. Similar disposition was made of a bill empowering the Bell Telephone Co. to extend its conduits on Third street from Vine to Callowhill, thence on Callowhill to St. John, to the centre of the square between Callowhill and Noble, and also on South street from Second to Front, and on Walnut from Water street to the Delaware river.

A bitter fight came to a close recently when the Fort Wayne-Jenney company received the contract for lighting the city of Bloomington, Ill. Three years ago the Thomson-Houston company, of Chicago, installed a plant in the city on the understanding that the municipality should have the option of purchasing it. There was determined opposition to the purchase of the Thomson-Houston plant, and the Fort Wayne Jenney decided to compete for the sale to the city of a complete outfit. The struggle became at once acrimonious; charges and counter-charges were so numerous that the citizens became intensely interested in the contest, and two factions were formed. Representatives of each company were honored by receptions by their respective partisans. Old friends quarreled about the relative merits of the two companies, and the fight became decidedly unique. The Fort Wayne Jenney obtained a majority in the council, and secured the contract at a bid of $70,000. Two hundred and forty lights will be supplied with current by eight dynamos. The lights will be suspended from mast arms.

Mention was made last month of the effort of several unfortunate stockholders of the defunct Great Western Telegraph Co. to escape the disagreeable duty of paying assessments on their holdings. Recently, another bill in chancery was filed by Senator Farwell and others, asking that a full accounting of the affairs of the company be had, in order that the rights of stockholders might be determined.

ELECTRIC LIGHT AND POWER.

THE HEISLER incandescent light system has been in operation over a year at Ogden, Utah, where its claims for long-distance transmission are put to the test of a distance of six miles from the water power station to the city. Very favorable reports of its success are made by Mr. David F. Walker, president of the Ogden Electric Light Co., including a gratifying statement on that most interesting point to investors—viz., the financial result. Mr. Walker says the plant has been "a financial success from the start."

PROVIDENCE, R. I.—The new station (now under construction) of the Narragansett Electric Lighting Co., of Providence, R. I., is carefully described and illustrated by the Providence *Sunday Journal*, of October 21st. The engines will be triple expansion, of 1,000 and 500 h. p., with steam jacketed cylinders and receivers. The Reynold's engines built by E. P. Allis & Co., of Milwaukee, have been selected. Mr. Reynold's has guaranteed an indicated horse-power on 12½ pounds of water per hour, which is said to be the lowest guarantee on which an engine was ever built. The engines will have cylinders 13-18-30 inches in diameter with 48 inches stroke. The fly-wheel will be 16 feet running at 100 turns per minute. The length of the boiler house will be 200 feet, with 12 batteries of boilers, and the entire lot will develop with the engines to be used, more than 10,000 h. p. The station will be equipped with the Thomson-Houston system for arc lighting and electric power, and the Westinghouse system for incandescent lighting.

THE WESTINGHOUSE ELECTRIC CO. have issued the most sumptious circular that we remember to have seen. As regards paper, letter-press, illustrations and binding, it is nothing less than lavish in its richness and elegance. Collectors of the unusual in any branch of publication who are fortunate enough to get possession of a copy will be quite sure to give it a place on their shelves as an example of the luxury to which business publications have attained. The circular is a large one—17 by 12 inches—and is bound in a heavy bronzed paper by copper rivets at the back, and heavily embossed in striking but chaste designs. In 63 pages—profusely and beautifully illustrated—are to be found descriptions of the lighting and motive power alternate current apparatus of the Westinghouse Electric Co.

THE EDISON ELECTRIC LIGHT COMPANY'S new pamphlet-circular exhibits a list of 169 central stations (in operation or under contract) employing the Edison system, with an aggregate of 391,305 lamps. The substantial character of the investments making now-a-days in the business of electric lighting is indicated in the buildings erected for central stations. The Edison circular includes among its illustrations well executed cuts of the station buildings at 26th street, New York; at Detroit, Mich.; at Philadelphia, and at Chicago, all being houses of an obviously superior and solid kind, befitting the location of established business enterprises. Interior views of several stations are also given.

A RECORD is kept of the life of the incandescent electric lamps used in the service of city lighting companies, and one lamp, a 20 c. p. Sawyer-Man, taken from the *Journal* counting room last week, showed a life of 5,000 hours, an exceptionally good record. Another recently taken off had 4,000 hours service to its credit.—(Providence, R. I.) *Sunday Journal.*

THE WESTINGHOUSE ELECTRIC CO. have contracted to furnish a plant of 25,000 lamps, Westinghouse alternate current system, to the Metropolitan Electric Supply Co., Limited, London.

THE HILL CLUTCH WORKS, of Cleveland, Ohio, have made a very successful move in the right direction, in undertaking the design and construction of power plants complete for electric lighting, including the designing and erection of station buildings. It has become a trite remark in electric light circles that illy considered power stations have been the bane of the business. As engineers and contractors, the Hill Clutch Works undertake station buildings and the complete line of power transmission machinery—in fact the entire light station with the exception of the electrical outfit. This method secures unity of plan throughout, and a single responsibility for the complete power station, and can hardly fail to be advantageous practically and economically. The large Brush plant at Minneapolis, was put in by the Hill Clutch Works a year ago, and they are now engaged upon the plant at St. Paul, which is nearing completion. This station is to have 2,500 h. p. of engine capacity, running 40 dynamos.

THE Westinghouse Electric Company have added 52 stations to their list since December last. Below is a list of them. This list comprises central stations only and does not include any isolated lighting plant.

LIST OF CENTRAL STATIONS, WESTINGHOUSE ALTERNATE CURRENT SYSTEM, ERECTED OR CONTRACTED FOR FROM DECEMBER, 1887, TO OCTOBER 15, 1888.

Location.	No. of 16 c. p. lamps	Operating Company.
Albany, N. Y	1,300	The Albany Electric Illuminating Co
Aspen, Col	650	Roaring Fork Electric Light & Power Co.
Aurora, Ill	650	Aurora Electric Light & Power Co
Black Hawk, Col	400	Stearns, Roger & Co
Braddock, Pa	650	Citizens' Electric Light Co
Chicago, Ill	1,500	Consumers' Electric Light Co
Downington, Pa	400	H. D. McFarlan
Eau Claire, Wis	650	Frank McDonough
" " ...1st increase.	650	" "
Elizabeth, N. J	650	Elizabeth Elec. Light. Heat & Power Co.
Englewood, Ills	750	Englewood Electric Light Co
Evansville, Ind	1,300	Evansville Gas and Electric Light Co.
Fort Worth, Texas	1,950	Fort Worth Electric Light Co.
Gainesville, Texas	650	Gainesville Gas Co
Hagerstown, Md.	1,300	Hagerstown Electric Co
Halifax, N. S	650	Chandler Electric Light Co., Limited.
Hoosac Falls, N. Y	1,300	Hoosac Falls Electric Light Co
Houston, Texas	650	Houston Elec. Light & Power Co., of 1887.
Joliet, Ill	650	Joliet Electric Light Co
Kingston, Ont	650	Kingston Electric Light Co., Limited
Little Rock, Ark	650	Little Rock Electric Light Co
Mansfield, Ohio	650	Mansfield Electric Street Railway Co
Maquoketa, Iowa	400	Barnes Brothers
" " ..1st increase.	250	" "
Marshall, Texas	650	Marshall Electric Light & Power Co.
Mendota, Ill	650	Mendota Electric Light Co
Montgomery, Ala	1,300	Brush Electric Light & Power Co
Newark, Ohio	650	Newark Electric Light & Power Co
New Bedford, Mass	1,300	New Bedford Gas Light Co
" " 1st increase.	650	" " "
" " 2d increase.	650	" " "
Norwich, N. Y	650	Norwich Electric Light & Power Co
Oakland, Cal	1,300	Oakland Gas Light & Heat Co
Olean, N. Y	650	Olean Electric Light & Power Co
Paducah, Ky	400	Paducah Gas Light Co
Palmer, Mass	650	Palmer Electric Co
Passaic, N. J	650	Passaic Electric Light, Heat & Power Co.
Pine Bluff, Ark	1,300	Pine Bluff Water & Electric Co
Pittston, Pa	1,300	Citizens' Electric Illuminating Co
Port Jervis, N. Y	650	The Deer Park Electric Light Co
Pueblo, Col	1,300	The Pueblo Light, Heat & Power Co.
Red Cloud, Neb	650	Red Cloud Electric Light Co
Richfield Springs, N. Y.	650	Richfield Springs Elec. Light & Power Co.
Salem, Ohio	650	Salem Electric Light & Power Co
" " ....1st increase.	650	" " "
San Bernardino, Cal	1,300	Elec. Light & Power Co., San Bernardino.
San Diego, Cal	1,300	Geo. D. Copeland
Sandusky, Ohio	1,300	Sandusky Elec. Light, Fuel-Gas & Sup. Co.
Shreveport, La	650	Shreveport Incandescent Elec. Light Co.
Sing Sing, N. Y	1,300	Sing Sing Electric Light Co
Sioux City, Iowa	650	Sioux City Electric Co
St. Paul, Minn	2,600	St. Paul Gas Light Co
Troy, N. Y	1,300	Troy Electric Light Co
Tyler, Texas	650	Tyler Electric Light Co
Weyers' Cave, Va	650	The Grottoes of the Shenandoah
Providence, R. I	2,000	Narragansett Electric Lighting Co
Beaver Falls, Pa	650	W. H. Hartman

Total number of stations to October 15, 1888 119
Total generating capacity on 16 c. p. lamp basis 199,100
" " " 10 c. p. " 318,560

MANUFACTURING AND TRADE NOTES.

MR. J. H. SHAY, of the Charles Munson Belting Co., has secured the contract for the belt equipment of the Brush Electric Light Co., of Baltimore, Md.

MR. CHARLES FELSING, analytical chemist, formerly with A. Merck, Darmstadt, Germany, has formed a business partnership with Mr. Chas. Reinmann, the glass-blower, for the manufacture of experimental apparatus.

MESSRS. JAS. W. QUEEN & CO., Philadelphia, send us their priced and illustrated catalogue of chemical apparatus. It makes a volume of no less than 364 pages, including a carefully prepared index. A list of chemical books is also included. The catalogue of apparatus and supplies is extremely comprehensive, while the illustrations and descriptive matter are well adapted for the information of students or others engaged in chemical work.

THE ROBERTSON LEAD ENCASING WORKS, 131 Water street, Brooklyn, N. Y., have patented a device for covering cables with a lead shield of any thickness while the insulating compound is being put on. They have made cables for several telephone companies, and their device is in use by a number of the large wire manufacturers.

THE WOODWARD ELECTRICAL CO., of Detroit, Mich., under the management of Mr. F. B. Trout, has done much to popularize the storage battery for central station installations. Their board of directors comprise a number of Michigan's most substantial business men.

THE "LAW BATTERY" in its latest form as supplied by the Law Telephone Co., 112 Liberty street, New York, exhibits several points of interest, particularly respecting the matter of durability. The negative element is a double cylinder. Both elements are secured beneath the glass cover, instead of passing through the cover in the usual manner. The cover, of blue glass, is tightly fitted, to prevent evaporation of water and creeping of salts.

PERFORATED LEATHER BELTING.—A novel method of preventing "air cushions" in belts run at a higher rate of speed, was patented by Messrs. Chas. A. Schieren & Co., of New York, May 24, 1888. Perforations are made through the belts in a regular and uniform manner, and at equal distances apart, over the entire surface, thus insuring equal tension and leaving the tensile strength of the belt uninjured. Besides preventing "air cushions" these belts are said to run smoother, steadier, and make less noise, than ordinary belts. They are well adapted to high speed dynamos, in which class are included those of the alternating current system.

AT THE CENTENNIAL EXPOSITION of the Ohio Valley, in Cincinnati, the Waterhouse Electric and Manufacturing Co. were awarded a gold medal and two silver medals on their arc light plant exhibited. The judges accord the system high praise, and the Waterhouse company are to be congratulated on receiving their second gold medal, the first having been awarded at the Mechanics' Fair, Boston, in December last.

THE C. & C. ELECTRIC MOTOR CO. invited a number of gentlemen to St. Paul's chapel on the afternoon of October 23, to examine the application of one of their motors to the blowing machinery of the chapel organ. Those who attended were much pleased by the successful performance of the C. & C. motor. The action of the motor is easily controlled automatically from the bellows.

MR. C. J. HIRLIMEN, so long identified with the manufacture of Leclanché batteries in this country, has begun the manufacture of a cell of his own design, for which several improvements are claimed. The company is known as the Improved Patent Porous Battery Co., limited, 89½ Greene street, New York city.

THE WESTINGHOUSE ELECTRIC CO. announces its lease of the Consolidated Electric Light Co. and the Sawyer-Man Electric companies, its intention being to conduct the business of those two companies hereafter.

The Westinghouse company has heretofore been a large stockholder in the Consolidated company, but under the new arrangement, will control absolutely the lamp trade under the Sawyer-Man patents, and can thus manage it in the interest of an extension of its business in dynamos and incandescent lighting apparatus, which is already one of the most important in the world. The combined lamp factories of the company will now have a capacity of 7,500 lamps daily, and by means of an improved process lately acquired, lamps will be produced which, it is claimed, will give a larger amount of light from a given expenditure of power than any company has heretofore guaranteed. It is expected that the improved method of manufacture will inure to the benefit of consumers in a considerable reduction in prices.

It is said that the terms of the lease are such as to secure to the stockholders of the Consolidated company a substantial dividend, thus placing the stock of that company on a paying basis.

THE EMPIRE CITY ELECTRIC CO., 15 Dey street, New York, manufacturers and dealers in electrical supplies, issues an illustrated list of domestic and other signal apparatus, bells, push buttons, etc. They make a point of the Empire City disque battery.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

ABBREVIATIONS.—**mi.**, miles of single track; **g.**, gauge; **lb.**, pounds rail per yard; **m.**, electric motors; **c.**, cars; **m. c.**, motor-cars; **h. p.**, horse-power; **T.**, T-rail. Name of electric system used is in SMALL CAPITALS.

Akron, Ohio.—Akron Electric Ry. Co. 6¼ mi.; 12 m. c.; overhead cond. SPRAGUE.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scaife; *Sec.*; Arthur Kennedy; *Tr.*, Jas. B. Scott; *Supt.*, Alexander Moffat; *Eng.*, —— 3-7 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 200 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.*, Jno. B. Wallace; *Sec.* and *Trea.*, Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½: 45 lb.; 3 m. c.; 1 m.; sta. —— h. p.; overhead cond. THOMSON-HOUSTON.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Tr.*, F. W. Harriman; *G. M.*, A. A. Johnson; *Eng.*, N. M. Edwards; 5.5 mi.; g., 4-8½; 35 lbs.; 6 m. c.; sta., 60 h. p.; water power; overhead cond. THOMSON-HOUSTON.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Se.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.; g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 8 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Birmingham, Ct.—Derby Horse Railway Co.—*Pr.*, H. H. Wood; *Sec.*, Wm. J. Clark; *Treas.*, Chas. E. Clarke; 4 mi.; 9¼′ 8½″; m 5; c. 4; h. p. 100. VAN DEPOELE.

Brockton, Mass.—East Side St. Ry. Co.—*Pr.*, A. F. Small; *Clerk*, C. A. Noyes; *Tr.*, C. D. Fullerton; *Eng.*, E. L. Brown; 4½ mi.; g. 4-8½; 40 lb.; 4 m. c.; steam-power sta. 60 h. p.; overhead cond; 4 m. c. SPRAGUE.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; *G. M.*, John Aldrich; 5 mi.; g. 4-8½; 30 and 60 lb.; 3 m. c.; 1 m.; steam power; sta. 75 h. p.; overhead cond. SPRAGUE.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper; *Sec.*, J. R. Murdock; *Tr.* and *G. M.*, G. B. Kerper; *Supt.*, R. Palley; *Eng.*, H. Kolf; 1 mi.; g. 5-2½; 52 lb.; 3 m. c.; 3 m. overhead cond.

Columbus, O.—Columbus Consolidated Street Ry. Co.—*Pr.*, A. D. Rodgers; 2 mi.; g. 5-2; 2 m. c.; 30 lbs.; 2 c.; sta., 250 h. p.; underground conduit. SHORT.

Crescent Beach, Mass.—Lynn & Boston St. Ry. Co.—1 mi.; 1 m. c.; overhead. THOMSON-HOUSTON.

Davenport, Iowa.—Davenport Central St. Ry.—*Pr.*, W. M. Grant; *Sec.*, G. S. McNeil; *Tr.*, J. B. Fidlar; *Supt.*, J. W. Howard; 3½ mi.; 8 m. c.; overhead cond. SPRAGUE.

Dayton, O.—White Line St. R. R. Co.—*Pr* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 12 m. c.; sta. 240 h. p.; overhead and conduit cond. THOMSON-HOUSTON.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 4 mi.; g.——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. THOMSON-HOUSTON,

Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit cond. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; *Supt.*, Mr. Richardson; 1 mi.; g. 5-2; 35 lb.; 2 m. c.; sta. 40 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1; 2 m. c.; ——h. p.; conduit. THOMSON-HOUSTON.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—*Pr.*, W. J. Calder; *Sec.*, D. Fleming; *Tr.*, T. D. Greenawalt; *Supt.*, J. Schaffner; 4.5 mi.; g. 5.2½; 52 lbs.; sta. 160 h. p.; 10 m. c.; overhead cond. SPRAGUE.

Hartford, Conn—Hartford & Weathersfield Horse R. R. Co.—*Pr.*, E. S. Goodrich; *Sec.*, D. R. Howe; 12 mi.; g. 4-8½; 45 lb.; 2 m. c.; overhead cond. SPRAGUE.

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, D. W. Burdick; *Sec.*, J. Murray Mitchell; *Tr.* T. F. Van Fleet; 1 mi.; g. 4-8½; 30 lb. T.; 2 m. c.; sta. 20 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 10 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Lafayette, Ind.—Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2.25 mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2¾ m.; g. 4-8½; 27-35-52 lb.; 9 m. c.; 9 Sprague cars. SPRAGUE.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 6 mi.; g. 4-8½; 40 lb.; T; 7 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Los Angeles, Cal.—Los Angeles Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p.; overhead cond. DAFT.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Meriden, Conn.—New Horse R. R.—*Pr.*, T. J. Lathram; *Sec.* and *Tr.*, T. A. Lamb; 5 mi.; g. 4-8½; 35 lb.; 12 m. c.; overhead cond. DAFT.

Meriden, Conn.—Meriden Horse R. R. Co.—*Pr.*, Geo. R. Curtis; *Sec.* and *Tr.*, C. L. Rockwell; *Supt.*, D. Barker; 5 mi.; g. 4-8; 35 lb.; 12 m. c. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. THOMSON-HOUSTON.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair St. Ry.—*Pr.*, Theo. Evans; *Tr.*, Henry Stamm; *Sec.*, J. W. Patterson; 2½ mi.; g. 5-2½; 43 lb.; 5 c.; 5 m.; steam-power; sta. 200 h. p.; overhead and conduit cond. DAFT.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt.*, Jas. H. Talbot; 4 mi.; g. 4-8½; 27 lb.; 6 m. c.; sta. 55 h. p.; overhead cond. THOMSON-HOUSTON.

Revere, Mass.—Revere Beach Ry. Co.—1 mi.; 1 m. c.; overhead. THOMSON-HOUSTON.

Richmond, Va.—The Richmond Union Pass. Ry. Co.—*Pr.*, W. R. Trigg; *Sec.* and *Tr.*, Andred Pizzini; *G. M.*; G. A. Burt; *Eng.* A. L. Johnston; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 400 h. p.; overhead cond. SPRAGUE.

Salem, Mass.—Naumkeag St. Ry. Co.—*Pr.*, C. Odell; *Tr.*, H. Wheatland; *Sec.*, J. F. Hickey; *Supt.*, W. B. Furgurson; 1½ mi. Willows branch; g. 4-8½; 6 m. c.; 35 lb.; 80 p. c.; sta. 100 h. p.; 6 m. c.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

San Jose, Cal.—San Jose & Santa Clara R. R. Co.—*Pr.*, S. A. Bishop; *Sec.*, E. Rosenthall; *Tr.*, J. Rich; *Supt.*, W. Fitts; 10 mi.; g. 3; 6 m. c.; sta. 130 h. p; conduit cond. FISCHER.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. McMaugh; *Eng.*, W. S. Smith; 5.75 mi.; g. 4-8½; 30 lb.; 4c.; 10 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

St. Joseph, Mo.—St. Joseph Union Pass. Ry. Co.—*Pr.*, Seymour Jenkins; *Sec.* and *Tr.*, A. Steinacker; *Supt.*, Chas. Wilson; 9½ mi.; g. 4-8½; 35 lb.; 8 m. c.; 13 m. c.; overhead cond. SPRAGUE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Tr.*, T. F. Torrey; *Supt.* and *G. M.*, B. T. Killam; *Eng.*, J. Nazel; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 10 m. c.; sta. 300 h. p.; overhead cond. THOMSON-HOUSTON.

Nayang Cross-Town Ry.—3 mi.; 4 m. c.; overhead. THOMSON-HOUSTON.

Scranton Pass. Ry.—2 mi.; 4 m. c.; overhead. THOMSON-HOUSTON.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, W. B. Cogswell; *Sec.* and *Tr.*, W. S. Wales; 4 mi.; g. 4-8½; 35-50 lb.; 8 m. c.; overhead cond. THOMSON-HOUSTON.

Washington, D. C.—Eckington & Soldier's Home Ry. Co.—2.14 mi.; 3 m. c.; overhead cond. THOMSON-HOUSTON.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 10 m. c.; sta. 240 h. p.; overhead cond. THOMSON-HOUSTON.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—*Pr.*, H. H. Sen; *Sec.*, W. E. Shupp; *Tr.*, C. Walter; *Supt.*, A. C. Robertson; 3-6 mi.; g. 5-2; 50 lb.; 7 m. c.; sta. 120 h. p.; overhead cond. SPRAGUE.

Wilmington, Del.—Wilmington City Ry. Co.—*Pr.*, W. Canby; *Sec.* and *Tr.*, J. F. Miller; *Supt.*, W. H. Burnett; 6½ mi.; g. 5-2; 47 lb.; 13 m. c.; overhead cond. SPRAGUE.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.5 mi.; g. 3-6; 25 lb.; 1 c.; 2 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb T; 1 m. c.; sta. 1,000 h. p.; overhead cond. THOMSON-HOUSTON.

Constructing or Under Contract.

Alliance, O.— 2 mi.; 3 m. c.; overhead. THOMSON-HOUSTON.

Asheville, N. C.—Asheville St. Ry.—3 miles; 4 m. c.; overhead cond. SPRAGUE.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—*Pr.*, H. G. Bacon; *Tr.*, J. E. Draper; *G. M.*, H. M. Daggert, Jr.; 6 mi.; g. —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond.

Bangor, Me.—Bangor St. Ry. Co.—5 mi.; 4 m. c.; overhead. THOMSON-HOUSTON.

Boston, Mass.—West End Ry. Co., Brookline branch.—12 mi.; 20 m. c.; overhead cond. SPRAGUE.

West End Ry. Co., Harvard Square Branch.—14 mi.; 20 m. c.; overhead. THOMSON-HOUSTON.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown; *G. M.*, E. Scott; 4 mi.; g. 4-8½; 25 lb.

Cleveland, O.—East Cleveland R. R. Co.—*Pr.*, A. Everett; *Sec.* and *Tr.*, H. A. Everett; *Supt.*, E. Duty; 23½ mi.; g. 4-8½; 45 lb.; 16 m. c.; overhead cond. SPRAGUE.

Danville, Va.—Danville St. C. Co.—*Pr.*, T. B. Fitzgerald; *Sec.* and *Tr.*, P. R. Jones; *Supt.*, M. W. Buckley; 1.6 mi.; g. 4-8½; 38 lb.; 2 m.c.; overhead cond. THOMSON-HOUSTON.

Des Moines, Iowa.—Capital City St. Ry. Co.—*Pr.*, G. Van Ginkel; *Sec.*, H. E. Teachout; *Tr.*, J. Weber; 7 mi.; g. 4-8½; 45 lb.; 8 m. c.; overhead cond. THOMSON-HOUSTON.

Elsinore, Cal.—Elsinore Lake Shore Elect. Ry. Co.—*Pr.*, D. G. Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.

Erie, Pa.—Erie City Pass. R. R. Co.—*Pr.*, W. W. Reed; *Sec.*, J. L. Sternberg; *Supt.*, Jacob Borst.; 8½ mi.; g. 4-8½; 20 m. c.; overhead cond. SPRAGUE.

Flushing, N. Y.—Flushing & College Point St. R. R.—*Pr.*, J. Dykes; *Sec.*, Charles Frey; *Tr.*, Henry Clement; g. 4-8½; 45 lb.; 1 mi.; storage bats.

Hudson, N. Y.—Hudson St. Ry. Co.—*Pr.*, H. McGonigle; *Sec.*, E. J. Hodge; *Tr.*, S. D. Loke; 2.5 mi.; g. 4-8½; 30-50 lb.; 3 m. c.; overhead cond. THOMSON-HOUSTON.

Lakeside, O.—3 mi.; 2 c.; overhead cond.

Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi.; g. 4-8½; 56 lb.; 10 m. c.; storage bats.

Louisville, Ky.—Central Pass. R. R. Co.—*Pr.*, B. du Pont; *Sec.*, J. C. Donigan; —— mi: g. 5.

Lynn, Mass.—Lynn & Boston Ry. Co.—*Pr.*, A. F. Breed; *Tr.* and *Clerk*, E. F. Oliver; *Supt.*, L. C. Foster; g. 4-8½; 2 m. c.; overhead cond. THOMSON-HOUSTON.

Manchester, Va.—Richmond & Manchester Ry. Co.—*Pr.*, J. E. Taylor; *V. Pres.*, J. Bryan; *Sec.* and *Treas.*, Jackson Brandt; *Supt.* B. R. Selden; 3¾ mi.; g. 4-8¾; 38 lb.; 10 m. c., 10 Sprague cars; overhead cond. SPRAGUE.

Minneapolis, Minn.—Minneapolis St. Ry. Co.—*Pr.*, Thos. Lowry; *Sec.* and *G. M.*, J. E. Rugg; *Treas.*, M. B. Koon; *Supt.*, D. W. Sharp; *Eng.*, E. T. Abbott; 69¾ mi.; g. 3-6; 27-35-45 lb.; 8 m. c.; overhead cond. SPRAGUE.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g. 4-8½; 52 lb.

New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*, E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.

New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; cond. conductor. BENTLEY-KNIGHT.

North Adams, Mass.—Hoosac Valley St. Ry.—*Pr.*, W. B. Baldwin; *Sec.*, S. P. Thayer; *M.*, H. A. Fitzsimons; 5 mi.; g. 4-8½; 40 lb.; 6 m. c.; overhead cond. THOMSON-HOUSTON.

Omaha, Neb.—Omaha and Council Bluffs Ry. & Bridge Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 9 mi.; g. 4-8½; 56 lb.; 12 m. c.; sta. 250 h. p.; overhead cond. THOMSON-HOUSTON.

Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.

Ottawa, Ill.— 6 mi.; 8 m. c.; overhead. THOMSON-HOUSTON.

Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.*, J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.

Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, F. H. Skeele; *Sec.*, E. H. Cook; *Tr.*, C. D. Newton; *V. P.*, M. Dillon; *Supt.*, T. M. Burt; 3 mi.; g. 4-8½; 38 lb.; 5 m. c.; overhead cond. DAFT.

Reading, Pa.—Reading & Black Bear Ry.—1½ miles; 2 m. c.; overhead cond. SPRAGUE.

Revere, Mass.—Lynn & Boston R. R.—Ocean Ave. line; overhead cond. THOMSON-HOUSTON.

Richmond, Va.—Richmond City Ry. Co.—*Pr.*, J. L. Schoolcraft; *Treas.*, Walter Kidd; *M.*, C. M. Bolton; *Supt.*, Charles Selden; 7½ mi.; g. 4-8½; 30-40 lb.; 50 m. c.; overhead cond. SPRAGUE.

Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.

St. Joseph, Mo.—Wyatt Park Ry. Co.—*Pr.*, J. M. Huffman; *Sec.*, I. R. Williams; capital, $300,000; 5 mi.; g. 4-8½; 10 m. c.; overhead cond.; 8 Sprague cars. SPRAGUE.

St. Louis, Mo.—Lindell Ry. Co.—*Pr.*, J. H. Lightner; *Supt.*, G. W. Baumhoff; *Eng.*, E. J. Bagnall; —— mi.; g. 4-10; 65 lb.; 1 m. c.; 2 m.; 3 p. c.; storage bats.

Sacramento, Cal.—Sac. Elect. Ry. Co. The Central Street Railway Co.—*Pr.*, L. L. Lewis; *Sec.*, E. K. Alsip; *Tr.*, F. Miller; *Supt.*, J. B. Austin; *Eng.*, ——; 13 mi.; g., 4-8½. Cars to be supplied by Electric Car Co, of America, Philadelphia.

Sault Ste. Marie, Mich.—S. St. M. St. Ry. Co.—*Pr.*, E. M. Lacy; *Sec.*, F. Ryan; *G. M.*, L. G. Cody; 2 mi. FISHER.

Sandusky, O.—Sandusky St. Ry. Co.—*Pr.*, Chas. V. Olds; *Sec.* and *Treas.*, A. C. Moss; *Supt.*, Clark Rude; 4 mi.; g. 4-8½; 32 lb.; 6 m. c.; overhead cond.; 6 Sprague cars. SPRAGUE.

Scranton, Pa.—The People's St. Ry.—*Pr.*, W. Matthews; *Sec.* and *Tr.*, H. E. Hayd; *Supt.*, F. Pearce; 10 mi.; g. 4-8½; 20 m. c.; overhead cond. SPRAGUE.

Seattle, Wash. Ter.—Seattle Electric Ry.—5 mi.; 3 m. c.

South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; (Enos elevated railway); 8 mi. 40 and 56 lb.; 10 m. c.; track conductors. DAFT.

Springfield, Mo.—2 mi. FISHER.

Steubenville, O.—Steubenville Electric Ry. Co.—2½ mi.; g. 4-8½; 40 lb.; 7% grade: 10 m. c.; overhead cond. SPRAGUE.

Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; *G. M.*, H. McGonegal; 4 mi.; g. 4-8½; 8 m. c.; 4 p. c.; steam power; sta. 250 h. p.; overhead cond. THOMSON-HOUSTON.

Tacoma, W. T.—Tacoma St. Ry.—*Pr.*, N. Bennett; 5 mi.; 4 m. c.; overhead. SPRAGUE.

Topeka, Kas.— 14 mi.; 30 m. c.; overhead. THOMSON-HOUSTON.

Wichita, Kas.—Riverside & Suburban Ry. Co.—*Pr.*, G. C. Strong; *Supt.*, O. J. Chapman; (contract for 2 miles); 7 mi.; 30-40 lb.; 3 m. c.; overhead cond. THOMSON-HOUSTON.

Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

RECAPITULATION.

Roads Now in Operation,	49
Roads Constructing or Under Contract,	49

Notes.

THE SOUTH ORANGE HORSE RAILROAD CO. is about to conclude arrangements with the Daft Electric Motor Co., to make a trial of the Daft electric railway system on the road between the stables and South Orange, provided the citizens along the line and the South Orange township committee give sanction to the erection of the poles and wires. The poles will be of octagonal yellow pine, painted and set in cement along the curb line on one side of the road, 100 feet apart, and each pole will carry an ornamental wrought-iron bracket from which the wires will depend. If the line is in every way satisfactory, endeavor will be made to get permission to continue it down through the city to the eastern end of the road.

THE THOMSON-HOUSTON ELECTRIC CO., since it took over the railway business of the Van Depoele company and entering into the construction and supply of street railway plant, have found it necessary to make a large increase in their manufacturing facilities in order to keep abreast with the remarkable growth in that branch of electrical work during the past year. The magnitude of the railway business has greatly exceeded their expectations.

THE SEATTLE, W. T. ELECTRIC RAILWAY AND POWER CO., of Seattle, Wash. Terr. was incorporated October 9th, by Frank H. Osgood, Edward C. Kilbourne, Thomas Burke, L. H. Griffith, G. M. Haller, Angus Mackintosh, and Victor H. Smith. This company was formed by the consolidation of the Seattle Street Railway Co. and the Electric Motor Co., for which Dr. Kilbourne recently obtained a franchise. It is now stated that the electric railway will be built at once. The capital stock of the new company is $120,000.

NEW YORK CITY.—The electric road of the North and East River Co.—Bentley-Knight system—is likely to be completed and in operation very shortly. Our readers will remember that work was suspended on this road nearly a year ago because of the opposition of the Bleecker Street Co. to the use of Fulton street by the electric company. An agreement between the companies is reported to have been reached, and it is expected that electric cars will be running by December 1st, connecting Fulton Ferry on the East river with the down-town North river ferries by way of Fulton street.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From September 25 to October 16, 1888.(inclusive).

Alarms and Signals:—*Hotel Signaling System*, A. Barrett and J. Zentner, 390,833. *Electric Bell-Pull*, P. A. Harris, 390,778, October 9. *Signaling Device*, J. Sax, 391,276, October 16.

Clocks:—*Apparatus for Synchronizing Clocks*, C. E. Hoefling, 390,230, October 2.

Conductors, Insulators, Supports and Systems:—*Electrical Conductor and Insulating Conduit*, R. F. Silliman, 389,948. *Elevated Frame-Work and Support for Electric Wires and Street Railways*, L. W. Brown, 390,001, September 25. *Device for Protecting Electric Conductors*, E. G. Acheson, 390,196, October 2. *Insulator or Bracket-Support for Electric Wires*, T. E. Adams, 390,741, October 9.

Distribution:—*System for the Distribution of Electric Energy*, G. and A. Pfannkuche, 389,974, September 25. *System of Electrical Distribution*, N. Tesla, 390,413. *Distribution and Control of Electricity for Lighting*, H. Edmunds, 390,463, October 2. *Coupling Dynamo-Electric Machines for Electric Distribution*, O. B. Shallenberger, 390,910. *Regulator for Electric Translating Devices*, same, 390,911. *Apparatus for Synchronizing Alternate-Current Dynamo-Electric Machines*, same, 390,912. *Synchronizing Electric Generators*, G. Westinghouse, Jr., 390,980. *System of Electrical Distribution*, O. B. Shallenberger, 390,990, October 9.

Dynamos and Motors:—*Electric Motor*, P. Diehl, 389,876. *Dynamo-Armature*, W. G. Meyers and F. E. Coward, 389,894. *Dynamo-Electric Machine*, W. Mather and E. and J. Hopkinson, 390,180, September 25. *Armature-Core for Dynamos*, W. S. Hill, 390,301. *Alternate-Current Dynamo*, E. Thomson, 390,318. *Dynamo-Electric Machine*, N. Tesla, 390,414. *Dynamo-Electric Machine or Motor*, same, 390,415. *Dynamo-Electric Machine*, C. S. Bradley, 390,439, October 2. *Dynamo-Electric Machine*, N. Tesla, 390,721. *Regulator for Alternate-Current Motors*, same, 390,820. *Electro-Dynamic Motor*, E. E. Ries, 390,904 and 390,905. *Multiple-Current Electric Generator*, same, 390,906. *Carbon Contact or Commutator Brush*, C. J. Van Depoele, 390,921. *Dynamo-Electric Machine*, J. Emmner, Jr., 390,955, October 9. *Dynamo-Electric Machine*, M. W. Parrish and W. R. Cole, 391,070. *Safety Attachment for Electric Motors*, C. F. Brush, 391,114. *Hand Magneto-Electric Machine*, J. B. Blair, 391,224. *Dynamo-Electric Generator*, G. and A. Pfannkuche, 391,270. *Regulation of Electric Motors*, L. S. Harris, 391,319, October 16.

Galvanic Batteries:—*Porous Cup for Galvanic Batteries*, E. M. Hewett, 390,597, October 2. *Galvanic Battery*, D. Humphreys, 390,674, 390,675, 390,676, and 390,677. *Battery Electrode*, H. J. Brewer, 390,748, October 9.

Lamps and Appurtenances:—*Electric Incandescent Lamp and Attachments*, I. W. Heysinger, 389,883, September 25. *Electric Arc Lamp*, R. H. Mather, 390,245. *Storm-Protector for Electric Lamps*, T. H. Brady, 390,440. *Process of Making Carbon Filaments*, T. A. Edison, 390,462. *Electric Light Circuit Cut-Off Switch*, W. A. Johnson, 390,481, October 2. *Globe for Electric Arc Lamps*, W. W. Downing, 390,846. *Incandescent Electric Lamp*, A. L. Reinmann, 390,903, October 9.

Measurement:—*Registering-Meter for Electric Currents*, J. D. Bishop, 389,870. *Galvanometer*, I. W. Chisholm, 390,067, September 25. *Electric Meter*, H. Bentz, 391,010, October 16.

Medical and Surgical:—*Galvanic Abdominal Truss*, L. Epple, 390,354. *Therapeutic Electrode*, J. H. Woodward, 390,544, October 2. *Galvanic Belt*, E. D. Granger, 391,364, October 16.

Metallurgical:—*Stack Furnace for Reducing Ores*, A. T. Hay, 390,964, October 9. *Device for Refining Metallic Ores*, H. H. Eames, 391,034, October 16.

Miscellaneous:—*Electric Testing Device for Card-Flats*, E. Tweedale, 390,101. *Electric Testing Device for Carding Machines*, J. Bullough, 390,113. *Electric Current Indicator*, P. B. Delany, 390,115, September 25. *Magnetic Cleaning Apparatus*, A. Hempel, 390,229. *Electrical Testing Apparatus*, J. W. Packard, 390,310. *Electric Circuit-Controller*, A. F. L. Willatowsky, 390,329, October 2. *Electrically-Operative Lock*, G. S. New, 390,795. *Electrical Stop Mechanism for Knitting Machines*, A. M. Newlands, 390,891. *Apparatus for Automatically Regulating the Flow and Temperature of Fluids*, G. A. Gustin, 390,960, October 9. *Electrical Switch*, J. S. Adams, 391,351, October 16.

Railways and Appliances:—*Railway Alarm*, A. G. Ingraham, 390,081, September 25. *Apparatus for Removing Ice from Railway-Tracks*, E. E. Ries, 390,619, October 2. *Electric Railway System*, D. G. Weems, 391,391, October 16.

Storage Batteries:—*Secondary Battery*, C. A. Faure, 389,882. *Electric Storage System*, W. H. McDonald, 389,935, September 25. *System of Utilizing Secondary Batteries*, H. Edmunds, 390,464, October 2. *Separator for Electric Batteries*, H. W. Butler, 391,229, October 16.

Telegraphs:—*Telegraphy*, S. D. Field, 389,888. *Telephonic, Telegraphic and Signaling Circuit*, E. I. Bernheim, 390,058, September 28. *Mechanical Telegraph*, J. B. Bennett, 390,642. *Telegraphy*, F. J. Patten, 390,802, October 9.

Telephones, Systems and Appliances:—*Telephone*, P. Wright, 390,428. *Telephonic Transmitting-Instrument*, R. D'Unger, 390,575, October 2. *Telephone Transmitter*, W. H. Collins, 391,356, October 16.

THE

ELECTRICAL ENGINEER.

Conducted by F. L. POPE AND G. M. PHELPS.

PUBLISHED MONTHLY AT

11 Wall Street, New York City.

TERMS OF SUBSCRIPTION.

United States and Canada, - - - - - - per annum,	$3.00
Four or more Copies, in Clubs (each) - - - - - "	2.50
Great Britain and other Foreign Countries within the Postal Union "	4.00
Single Copies, - - - -	.30

[*Entered as second class matter at the New York, N. Y., Post Office, April 9, 1888.*]

EDITORIAL ANNOUNCEMENTS.

Addresses.—*Business letters should be addressed and drafts, checks and post-office orders made payable to the order of* THE ELECTRICAL ENGINEER. *Communications for the attention of the editors should be addressed,* EDITOR OF THE ELECTRICAL ENGINEER, *11 Wall Street, New York city.*

Communications *suitable for our columns will be welcomed from any quarter. Discussions of subjects relating to all branches of electro-technical work, by persons practically acquainted with them, are especially desired. Unavailable and rejected manuscripts will be returned only when accompanied by the necessary postage.*

Advertisements.—*We can entertain no proposition to publish anything for pay, or in consideration of advertising patronage, except in our advertising columns. Our editorial columns will express our own opinions only, and we shall present in other columns only such matter as we consider of interest or value to our readers.*

VOL. VII. NEW YORK, DECEMBER, 1888. No. 84.

SPECIAL NOTICE.—To afford an opportunity to become acquainted with THE ELECTRICAL ENGINEER, *the publishers will send it to any new address for* THREE MONTHS *for* FIFTY CENTS.

By arrangement with the publishers of the ELECTRICAL WORLD, *New York, and the* WESTERN ELECTRICIAN, *Chicago, the publishers of this journal are enabled to offer either of those weekly papers together with the* ELECTRICAL ENGINEER, *for* $5.00 *per year or the three journals for* $7.50. *To those of our present subscribers who so desire, we will supply either the* ELECTRICAL WORLD, *or the* WESTERN ELECTRICIAN, *one year for* $2.50, *or both for* $5.00.

WITH OUR ROAST TURKEY.

MAY not electricians join heartily in the grateful felicitations of the good old New England holiday this year? Benefits resulting chiefly from persistent and well-directed toil by the recipients far outrank all bounties as cause for gratitude. Earned success is the only real success. From this point of view the fruits of the past year's work in the electrical field may well entitle all participants, scientific, industrial or commercial, to a cheerful and gracious part in the celebration of Thanksgivng Day. Research, practical application and commercial utilization have not only maintained but have accelerated their pace, their mutual action and reaction constantly inciting to renewed and greater efforts and leading to more decisive and far reaching successes.

In the field of electrical applications reduced to commercial use the most striking feature of the year is to be found in electric street railway service. Not only has the business grown beyond all expectation in amount, but much improvement has been effected in its electrical and mechanical features. The establishment of an electric road is no longer looked upon as a formidable undertaking, nor is its operation regarded as a curiosity by the public. December 1st, a year ago there were 21 electric roads in operation in America; to-day there are 52, while 47 are under construction or contracted for. Cheap and poor line construction and ill adapted mechanical details, found too frequently in much of the early work on railways, are being discarded in new work and replaced in old (the old story, but promising to be less prolix in this instance than it has been in other cases). Much yet remains to be accomplished in electric traction, but the great gains of the closing year, technical and commercial, are abundantly apparent.

The rate at which electric motors have been installed for stationary power is scarcely less noticeable than the development of electric traction during the year. About the first of September, it was estimated that 6,000 electric motors were driving machinery in the United States. A thousand have probably been added since. It seems reasonable to estimate the number put in operation for the year at not much less than 4,000.

The use of the storage battery as a means of distribution may fairly be said to have made relatively slow advancement, while in many special cases its employment has been of great value and importance. Its problems have had and continue to enlist the close attention and skill of many able investigators and inventors, and it cannot be doubted that the moderate success thus far attained by this obviously important and necessary means of distributing electricity will be followed not long hence by such improvements as will make the accumulator a general and trustworthy instrument in electrical engineering.

The electric light, arc and incandescent, has become so familiar to everybody, even in the far western territories, that its continued rapid spread no longer attracts attention. It is expected everywhere; its absence in any considerable town is more noticed than its presence. Great activity in the installation of central station plants has prevailed during the year, especially in incandescent lighting. The success of the alternating current method of distribution in covering large areas of relatively sparse consumption has largely stimulated the demand for electric lighting in the smaller towns of the country, and has also contributed not a little towards inciting the companies whose business is based upon other methods of distribution to improving the capacity of their apparatus and the serviceableness of their lamps. The life of lamps has been materially prolonged, while a reduction has been effected in the amount of energy required per candle-power. Whatever may be thought of the policy of competition in prices, there can be no question of the general benefit of competition in the efficiency and trustworthiness of apparatus and lamps. Competition of

the former kind, while severe, has crippled only the weak, while that of the latter sort has resulted in advantage to both producers and consumers.

The practical success of the employment of alternating currents has re-acted in the laboratories of scientific research, and led to the study of new questions, or old questions in a new light; study and experiment which have already done much to clear the path of the practical electrician in his work, and which indicate the early acquisition of further electrical knowledge of great significance.

The year's scientific and practical advances are great enough for congratulation, but not great enough to induce complacent satisfaction and relaxation of effort.

ELECTRIC LIGHTING IN ENGLAND.

PROJECTS for central station electric lighting on a large scale in England are following one another with great rapidity, in London and in provincial towns as well. This recent activity is doubtless due in large measure to the improved situation of the capitalists who undertake such enterprises, consequent upon the modification by parliament, of the onerous restrictions of earlier legislation touching their privileges, and still more perhaps to the widespread and successful introduction of the alternating current and transformer method of distribution for large areas. In another column of this issue we reprint some account of the Deptford station now erecting by the London Electrical Supply Corporation, which now operates the Grosvenor Gallery station. This company will compete with the Metropolitan Electrical Supply Co., Limited, who are about to install a Westinghouse plant, as noticed in our November number. Mr. Ferranti's alternating current apparatus will be employed in the Deptford plant, which is laid out on a very large and comprehensive plan. As reported by the *Electrician*, of London, the number of lamps now wired from the Grosvenor Gallery station, is equivalent to about 35,000 10 c. p. (say 22,000 16 c. p.) lamps, a maximum of 20,000 (12,500 16 c. p.) being in use at one time. From the plans of the two companies it appears that at no distant day the central portion of London will be provided with station capacity for some 75,000 16-c. p., or 120,000 10-c. p. lamps. A third large undertaking is heralded in London—the St. James Electric Light Co.—a preliminary announcement stating that their station is designed for 20,000 lamps, of which 5,000 will be used from the start. The uneasiness of the gas companies under this state of things is exhibited in the announcement by one of them of a reduction of 3*d.* per 1,000 feet to all consumers north of the Thames. The *Gas and Water Review* says, "It would be well if gas companies would take some combined action and secure the right to supply electricity as well as gas. This is very largely done in America."

ELECTRICIANS and electrical engineers are no doubt, for the most part, too greatly occupied in worthy professional work to interest themselves very much in the problem how best to apply their art to the execution of criminals in accordance with the Act of the New York Legislature, ordaining the displacement of the gallows by the electric current after the first of January next.

The Medico-Legal Society undertook the task some weeks ago, by appointing Dr. Frederick Peterson, Dr. J. Mount Bleyer, Dr. Frank H. Ingram, and Professor R. Ogden Doremus, a committee, to report the best method of putting the new law into practice. The report of the committee was made to the society on the 14th of November, and is printed *in extenso* by an electrical contemporary, accompanied by some ghastly illustrations.

Readers who are not greatly concerned about the particular method to be employed in despatching murderers may perhaps find some interest in the following contribution to electrical knowledge, extracted from the report of the committee.

> There are several points requiring thoughtful consideration in the application of death currents to man, which we now proceed to lay before you.
>
> The average resistance of the human body is about 2,500 ohms. The most of this resistance is in the skin. It is evident, therefore, that the larger the surface of the electrode applied to the body, the greater will be the resistance. It is also a fact that the density of the current depends upon the superficial area of the electrode. A pole of small diameter will hence meet with less resistance, the passing current will be more intense, and the resulting current strength will be greater than when an electrode of large sectional area is applied.

THE decision of the Supreme Court of the United States, announced November 12th, in the suit of the Government against the American Bell Telephone Co. (on appeal from the U. S. Circuit Court, Massachusetts District, where the bill had been dismissed on the demurrer of the defendant, September 26, 1887), sustains the claim of the Attorney-General of the right to bring the suit in equity to cancel the patents in issue, remanding the case to the lower court.

This remarkable judgment seems less ominous to the Bell Telephone Company than to the interests of the owners of patents generally. Apparently all the allegations of the Attorney-General's bill, including the charges of fraud, have been passed upon in the various infringement suits by circuit and district courts, and their concurrent judgments sustaining the Bell patents were confirmed by the Supreme Court in its decision of the appealed cases last March. It seems, therefore, that the Bell company has little to fear in a trial of the government suit on the merits.

In respect to the interests of property in patents generally, the precedent made by the Supreme Court in this case is ominous because it furnishes a new weapon of attack upon profitable patents to the hands of infringers and speculators however thoroughly such patents may have been sustained in repeated trials before the national courts up to and including the judgment of the Supreme Court.

WE note with grief that two of our valued electrical contemporaries have been exchanging bad language all the way across the Atlantic. Some rather ill-natured comment on American "smartness" on the part of an English journal was too much for the equanimity of a western editor, who indignantly expressed his feelings in good set terms. This evoked further revilings from London, including antique gibes about "wooden nutmegs and clocks that won't go." Let us hope that these latter allusions are not intended to refer in any way to American dynamos and other electric lighting machinery, which not only go here, but

have already begun to go over the sea to London, where they will soon be in service on a large scale. To the allegation of "smartness" in its offensive sense, America is apparently neither more nor less amenable than Great Britain, or other commercial countries, and we may bear with unruffled composure any flings at our methods in electrical development so long as we keep up our lead of the rest of the world in the variety and extent of our electrical industries.

In respect to the contention between the Telephone company and the Common Council at Chicago, over the attempted municipal regulation of charges, fully noticed in our recent and present correspondence columns, we are advised —too late for insertion in Chicago letter—that the Corporation Counsel has announced his opinion that the city council has no right to interfere with telephone charges. He finds that no authority for such interference is conferred by the city charter. The council is balked, therefore, in its effort to regulate the business of the telephone company. It seems to be the prevailing impression that the council will petition the legislature to grant the requisite power. No action as to the attitude of the city in the meantime has been taken. Many of the aldermen favor a temporary compromise.

The Committee on Science and the Arts of the Franklin Institute desire it to be generally known that they are empowered to award, or to recommend the award of, certain medals for meritorious discoveries and inventions, which tend to the progress of the arts and manufactures.

These medals are:—1. The Elliott Cresson Medal (gold). This medal was founded by the legacy of Elliott Cresson, of Philadelphia. It will be granted, after proper investigation and report by sub-committee, either for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process, or combination of materials in manufactures, or for ingenuity, skill, or perfection in workmanship. 2. The John Scott Legacy Premium and Medal ($20 and a medal of copper). The John Scott Legacy Premium and Medal was founded in 1816, by John Scott, a merchant of Edinburgh, Scotland, who bequeathed to the City of Philadelphia a considerable sum of money, the interest of which should be devoted to rewarding ingenious men and women who make useful inventions. The premium is not to exceed $20, and the medal is to be of copper, and inscribed "*To the most deserving.*"

Upon request therefor, from interested persons, made to the secretary of the Franklin Institute, Philadelphia, full information will be sent respecting the manner of making application for the investigation of inventions and discoveries.

OBSERVATIONS.

A brief, but practical and valuable paper, was that read by Mr. W. H. Preece, before the British Association, Section A, last September, "On the C. G. S. and Practical Units of Measurement." Mr. Preece advocates the adoption of the *jóule* as a thermal unit, equivalent to 10^7 ergs, as proposed by Sir William Siemens in 1883. This, as he truly points out, would be a great help in calculation. A more important thought suggested in the same paper, is that of the extreme inconvenience which arises from the difference in value of the ampere and the C. G. S. unit of current. This is because the volt has been accepted as equal to 10^8 instead of 10^9 C. G. S. units, which of course makes the ampere one-tenth of the C. G. S. unit current. Nobody seems to know a really first-class reason in favor of the present value of the volt, but the one which Mr. Preece says has been given, is that the volt represents very nearly the E. M. F. of a Daniell cell; which is, of course now, no reason at all.

He would like the British electricians when they attend the conference at Paris, next year, to be armed with an opinion of the British Association, that 106.3 c. m. represents more nearly than 106, the true ohm; and that the volt should be made equal to 10^9 C. G. S. units of E. M. F.

. . .

The profession has grown so immensely since 1882, when we were first introduced to the ampere, that to many of the fraternity that period must look like antiquity.

There are, however, a goodly number still at the fore, who well remember that it came as a kind of shock to us, who had grown familiar with a unit of current called the *Weber* (or as it was sometimes barbarized, *Veber*), to hear that henceforth we were to know that name no more; that the same unit of current must hereafter, if we wished to be in good form, be called the *ampere*.

It seemed clumsy for a while, but the tremendous influx of new men who had nothing to unlearn, carried the day.

. . .

And after all was it not well to commemorate the French scientist, who established the science of electro-kinetics by associating his name with the unit of current. We would not now have it changed. How much the simple formula $C = \frac{E}{R}$ means to all of us. All honor to him who worked out the laws of currents without its aid.

These observations contained a word on Green, last month. Let us take a look at Ampere this month.

André-Marie Ampere.—Born January 22d, 1775. Died June 10th, 1836, aged 61. In 1793, his father died by the guillotine, a victim of the Revolution.

As an electrician his great work, and that upon which his fame mainly rests was his exposition of the science of electro-magnetism, or electro-kinetics, which indeed he may be said to have founded. He first heard of Oersted's discovery that a magnetic needle may be deflected by a voltaic current, on September 11th, 1820, and within eight days thereafter, on the 18th of the same month he presented a complete analysis and explanation of the phenomenon, a masterly piece of work.

He also formed and adopted the theory that all magnets, including the earth, were produced by the continuous circulation of electric currents in closed circuits around them.

In October, 1820, he suggested an electric telegraph in which magnets were to be deflected by the action of conducting wires, one for each letter, each wire being connected with a key at the transmitting station, which when depressed would make contact with a battery. This however never advanced beyond the region of suggestion.

A more important work was his invention of the double or astatic needle, which is described in his memoir of 1821. This idea is usually ascribed to Cumming or Nobili, and indeed Cumming invented a very similar device shortly thereafter.

Ampere was also the author of the celebrated expedient of determining the position of the needle in relation to the current, by imagining a man swimming in the stream.

Those wishing to know more of this philosopher can profitably refer to the Encyclopedia Brittanica article on Ampere; to "A History of Electric Telegraphy," by J. J. Fahie, pp. 275–303, and to Brennan's "Electricity and its Discoverers."

ARTICLES.

DYNAMO REGULATION BY MEANS OF A THIRD BRUSH.[1]

BY EDWARD CALDWELL, A. B., M. E.

THE following study of methods of third brush regulation of series dynamos for *constant current*, was taken up at the suggestion of Professor Nichols. During the progress of the experimental work it was discovered that a similar method of regulation might be applied to a series-wound dynamo for the production of a *constant electromotive force*. The investigation was made to include, therefore, the applicability of this method of regulation to a series-wound dynamo, both for a constant current and a constant electromotive force.

The dynamo used in this work was a small series-wound machine, with two upright field magnets of the Edison type and a Gramme armature. The cores and yoke were of the best Norway iron. The principal dimensions and constants of the machine were as follows :—

Diameter of armature, outside..............	$4\frac{3}{4}$ inches
Length " " "	$2\frac{1}{4}$ "
No. " " coils..................	80
Resistance " through brushes.....	.72 ohm.
Diameter of field magnet cores.............	$2\frac{3}{8}$ inches.
Length of field magnet cores..............	$7\frac{3}{8}$ "
Size of yoke.................... 2″ × $2\frac{3}{8}$″ ×	$10\frac{1}{4}$″
Turns of wire on each field coil..............	785
Resistance of each field coil..........	.8 ohm.

A third brush, held by an independent brush holder, was placed upon the commutator between the regular brushes. This could be set at any desired angle in advance of the positive brush, a pointer indicating the angle upon the graduated circumference of a wooden ring placed concentrically with the shaft. Another pointer indicated in a similar manner the angular lead of the regular brushes. Each of these pointers was set at zero of the graduated scale when the brush which carried it rested at the upper end of the vertical diameter of the commutator—a point midway between the edges of the pole-pieces.

The field was explored for distribution of potential around the commutator by a modification of a method described by Professor Brackett, in a paper read before the American Institute of Electrical Engineers in 1884, and published in vol. i. of the *Transactions*.

The current was measured by a tangent galvanometer, the coil being formed of a single ring of copper, 50 centimeters in diameter, and of rectangular cross-section. Its constant was determined by comparison with the large standard tangent galvanometer, in the Magnetic Observatory of Cornell University. The deflections could easily be read to tenths of a degree.

The E. M. F. was measured by an Ayrton and Perry voltmeter which had previously been calibrated. The voltmeter was shunted across the regular brushes of the machine.

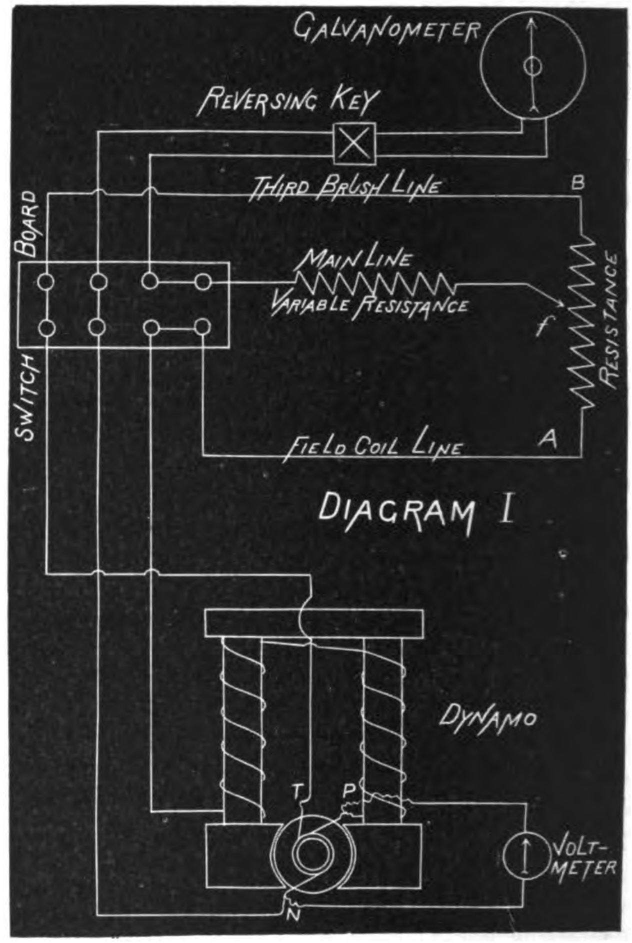
The resistances used in the external circuits were made of german-silver wire coiled in the form of a spring and stretched upon upright wooden frames. By means of a copper hook, contact could be made at any desired point. These coils were standardized by comparison with the coils of an Elliott Bros. resistance box of the dial pattern.

The arrangement of the apparatus during the first portion of this investigation differed from that of the Waterhouse Electric Co., in their system of third brush regulation for constant current[2], only in that the point of contact of the main line with the resistance coils of the regulator was varied by hand instead of by automatic means.

1. Revised abstract of graduating thesis, Sibley College, Cornell University, June, 1888.

2. See *Electrical World*, Sept. 29, 1888.

The connections used are shown in diagram I. The switch-board contained eight small mercury cups—two each for the terminals of the galvanometer, the third brush line, and the main line, and was so arranged that the galvanometer could be placed in any one of the three circuits.



The machine was first run at 2,500 revolutions as an ordinary series machine with two brushes, these being adjusted to the non-sparking position with a lead of about 12.° Table 1 gives the data obtained from which the characteristic curve in plate A is plotted.

TABLE 1.

Volts.	Amperes.
11	.21
89	.87
49	1.54
54	2.35
55.1	3.09
54.6	4.11
51.	6.90

It will be noticed here that a very small amount of current is sufficient to saturate the field magnets, because of the very large number of turns of wire on the field coils.

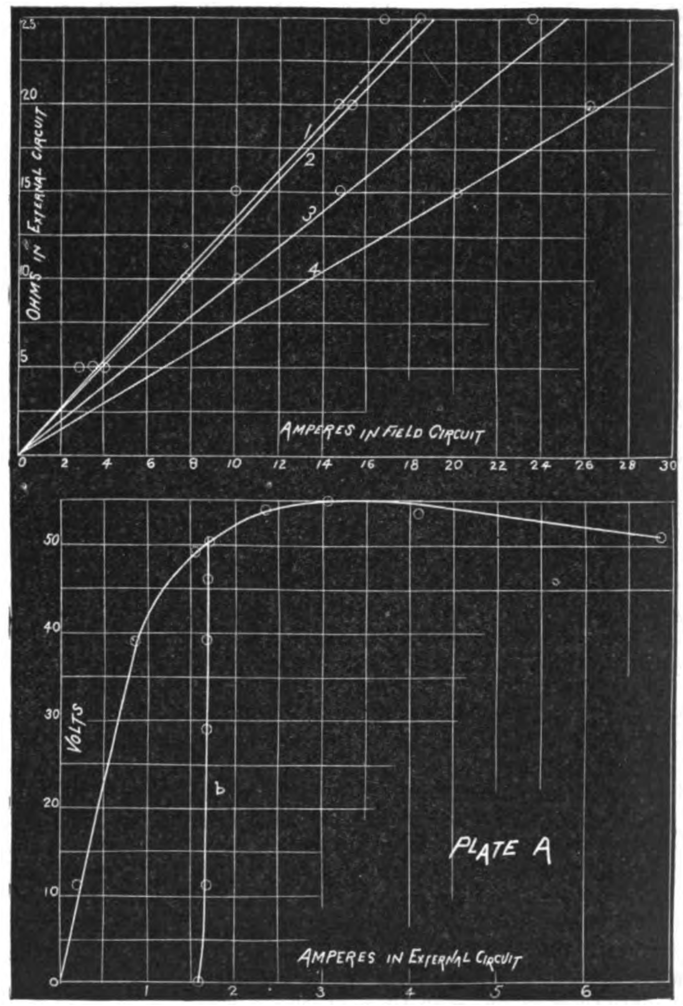
With the third brush upon the commutator a study was made of the effect of increasing the angular distance between the third and positive brushes. The tabulated results are given in tables 2 to 6. The third brush remained fixed through each set of observations, and the main brushes, at a lead of 12°, through all the five sets. The resistance between the third and positive brushes was 21 ohms.

	Volts.	Amperes main line.	Amperes field line.	Amperes third br. line.	Ohms in main line.	Extra res. in field.	Angular advance of third brush.
Table 2.	11.	1.70	.39	1.31	5	16.5	24°
	29.	"	.77	.93	10	12.9	
	39.	"	.99	.69	15	9.4	
	46.1	"	1.47	.23	20	5.1	
	50.	"	1.68	.02	25	1.4	
Table 3.	7.	1.70	.29	1.41	5	19.3	48°
	29.	"	.78	.92	10	15.1	
	41.2	"	1.12	.58	15	12.0	
	49.	"	1.52	.18	20	7.9	
	52.3	"	1.84	-.14	25	3.0	
	53.5	"	1.96	-.26	30	0.	
Table 4.	12.	1.70	.35	1.35	5	20.	72°
	35.	"	1.01	.69	10	16.8	
	47.7	"	1.48	.22	15	11.4	
	51.6	"	2.05	-.35	20	6.5	
	53.4	"	2.35	-.65	25	2.3	
Table 5.	43.	3.23 (?)	1.09	2.16	5	21.	96°
	47.	1.84 (?)	1.24	.60	10	21.	
	53.5	1.70	2.13	-.43	15	10.	
	55.1	"	2.61	-.91	20	5.	
	55.0	"	2.76	-1.06	25	2.5	
Table 6.	51.	1.70	1.88	-.18	5	21.	120°
	54.3	"	2.61	-.91	10	12.	
	55.1	"	2.68	-.98	15	9.9	
	55.3	"	3.06	-1.38	20	4.7	
	55.3	"	3.37	-1.67	25	1 7	
Table 7.	29.	1.70	.77	.93	10	12.9	24°
	29.	"	.78	.92		15.1	48°
	35.	"	1.01	.69		16.8	72°
	47.	——	——	.60		21.0	96°
	54.3	1.70	2.61	-.91		12.0	120°
Table 8.	39.	1.70	.99	.69	15	9.4	24°
	41.2	"	1.12	.58		12.0	48°
	47.7	"	1.48	.22		11.4	72°
	53.5	"	2.13	-.43		10.	96°
	55.1	"	2.68	-.98		9.9	120°
Table 9.	46.1	1.70	1.47	.23	20	5.1	24°
	49.0	"	1.52	.18		7.9	48°
	51.6	"	2.05	-.35		6.5	72°
	55.1	"	2.62	-.91		5.0	96°
	55.3	"	3.08	-1.38		4.7	120°
Table 10.	50.	1.70	1.68	.02	25	1.4	24°
	52.3	"	1.84	-.14		3.0	48°
	53.4	"	2.35	-.65		2.3	72°
	55.0	"	2.76	-1.06		2.5	96°
	55.3	"	3.37	-1.67		1.7	120°
Table 11.	1.	1.00	.10	.90	5	18.7	36°
	10.	"	.32	.68	10	16.6	
	28.	"	.40	.60	15	13.0	
	29.	"	.62	.38	20	11.8	
	33.	"	1.00	.0	30	4.0	
	40.5	.92	1.07	-.15	40	0.	
Table 12.	5.	1.50	.31	1.19	5	17.4	36°
	25.4	"	.49	1.01	10	14.9	
	34.0	"	.83	.67	15	11.5	
	41.2	"	1.22	.28	20	6.0	
	45.	1.38	1.56	-.18	30	0.	
Table 13.	14.0	2.00	.48	1.52	5	16.5	36°
	34.5	"	.81	1.17	10	13.0	
	44.	"	1.48	.52	15	6.8	
	47.5	"	2.00	.0	20	0.4	
	45.0	1.38	1.56	-.18	30	0.	
Table 14.	25.	2.50	.61	1.89	5	15.8	36°
	43.6	"	1.50	1.00	10	9.0	
	47.7	"	2.38	.12	15	1.7	
	48.0	2.14	2.22	-.08	20	0.	

The curves of relation of E. M. F. and current, of which curve *b*, plate A, is an example, need not be plotted, as an inspection of the tables will show, that within the limits of regulation, the curves are superposed vertical lines, if the volts be taken as ordinates and the amperes as abscissæ. Curves 1 to 4, plate A, are plotted from tables 2 to 5.

These curves are straight lines, and they show that the condition necessary to constancy of current in a series dynamo, namely, direct proportionality of external resistance and current in the field coils, has been secured. They also show that the greater the lead given to the third brush, the greater the field current necessary to keep the external current constant, the external resistance being the same. This will also be seen by a comparison of columns 3 and 7 in tables 7 to 10. These tables are compiled from tables 2 to 6.

But the most interesting as well as the most important phenomenon shown by all of these tables alike, is the change of sign of the current in the third brush line. Under some conditions the third brush acts as a positive brush, and under others as a negative.



Tables 2 to 6 show, (1) that with each position of the third brush, on increasing the external resistance, the current in the third brush circuit at first decreases, becomes zero, and again increases in the opposite direction; and, (2) that the further the third brush is in advance of the positive, the higher is the current in the third brush line at first, the sooner the zero point is reached, and the higher the current rises in the opposite direction.

Tables 7 to 10 show, (1) that with advance of the third brush, the external current and resistance being kept constant, the E. M. F. continues to rise while the current in the third brush line gradually decreases, passes through zero, and again increases in a negative direction; (2) that this zero point is also the point of maximum additional

resistance in the field, and of minimum additional resistance in the third brush line; and, (3) that this zero point is reached sooner the higher the external resistance.

It was at first thought that these changes might be due to a distortion of the neutral line of the armature, since with each change in external resistance there was a corresponding change of strength of field, while the current flowing up through the armature from the negative brush remained constant. An exploration of the field, however, by the method alluded to, showed that under extreme variations of current in the field, the neutral line did not change position as much as 10°,—an amount quite insufficient to account for the changes shown in the tables.

It will be noticed that the application of the third brush destroys the symmetrical flow of current in the armature. If the third brush be positive it will take off a part of the current flowing up on that side of the armature, and the coils lying between the third and positive brushes will have less current than the other coils. But if the third brush be a negative, the current returning to the armature by the third brush line will be added to the coils lying between the third brush and the positive. Neither will the current flowing up on one side of the armature be equal to that on the opposite side, since the resistances of the two paths offered to the current are not equal. The result of this unequal distribution will be, in extreme cases, to throw the neutral points of the armature off the ends of a diameter and on that side of a diameter where the coils are traversed by the weaker current. If, however, as was the case with the machine used in this investigation, the magnetic moment of the field is very great as compared with that of the armature, this effect is inappreciable.

But these variations of current in the third brush line may be satisfactorily explained without reference to the distortion of the diameter of commutation. It is a well-known fact that the total E. M. F. generated in the armature coils increases around the commutator from the negative brush to the positive, each coil adding its share to that induced in the coils preceding, and that the E. M. F. again falls, through the same range, from the positive brush around the external circuit to the negative brush.

Let E_d be the drop of potential between the positive brush and the point at which the third brush line joins the main circuit, and let E_1 be the rise of potential between the third and positive brushes,—that is, the E. M. F. induced in the coils which lie between these brushes.

It is evident that if $E_d = E_1$, no current will flow in the third brush line, its two ends being at exactly the same potential. But if $E_d > E_1$, the third brush will be at a point of higher potential than the other end of the third brush line, and current will flow *out of* the armature through the third brush. If $E_d < E_1$, the reverse effect will be produced, and current will flow along the third brush line *into* the armature.

Now $E_d = C' R'$, where C' and R' are respectively the current and resistance of that part of the circuit between the positive brush and the junction of the third brush line with the main line. Also,

$$E_1 = \frac{2}{\pi}\, w\, H'\, A'$$
$$= 4\, n\, H'\, A'.$$

A' being the "equivalent area" of the coils lying between the third and positive brushes; H', the strength of field; w, the angular velocity; and n, the number of revolutions per second of the armature.

There will be equilibrium between the ends of the third brush line when $E_d = E_1$, that is, when

$$C' R' = 4\, n\, H'\, A'.$$

The speed remaining constant, this equation shows that any one of three changes will make $E_d > E_1$, and so make the third brush positive.

(1) *Increase of R'.*
This will occur if the finger, *f*, diagram i., be moved toward the point B. This change will produce a corresponding decrease of C' and H', but below the saturation point these practically vary in direct proportion, and will not change the value of the equation.

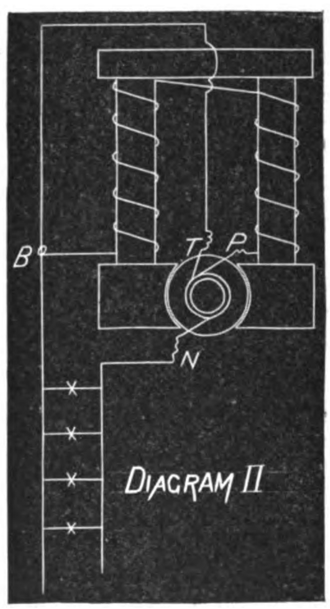
(2) *Decrease of A'.*
This may be done by bringing the third and positive brushes nearer to each other, thus decreasing the number of coils between them.

(3) *Increase of C'*, the field magnets being saturated.
If H' remain practically constant because of the saturation of the iron, an increase of C', caused by a decrease of the resistance of the external circuit, will make $E_d > E_1$.

The three opposite changes will make $E_d < E_1$, viz.:—
(1) *Decrease of R'.*
(2) *Increase of A'.*
(3) *Decrease of C'*, the field magnets being saturated so that H' remains constant.

A change of speed, n, would produce a complex change in all of the factors, except A'. All of the variations of current in the third brush line may be traced to one or more of these causes.

It will be noticed that the difference of potential between the main brushes is always the same—between 50 and 51 volts—when the current in the third brush line changes sign. This is the point at which the new characteristic crosses the characteristic of the regular series machine, as shown in plate A, where the characteristic curves from tables 1 and 2 are plotted together. When the third brush is positive it robs the field coils of a part of their current and adds this to the main line current, and when it is negative it diverts a portion of the current from the main line, adding it to the field circuit line.



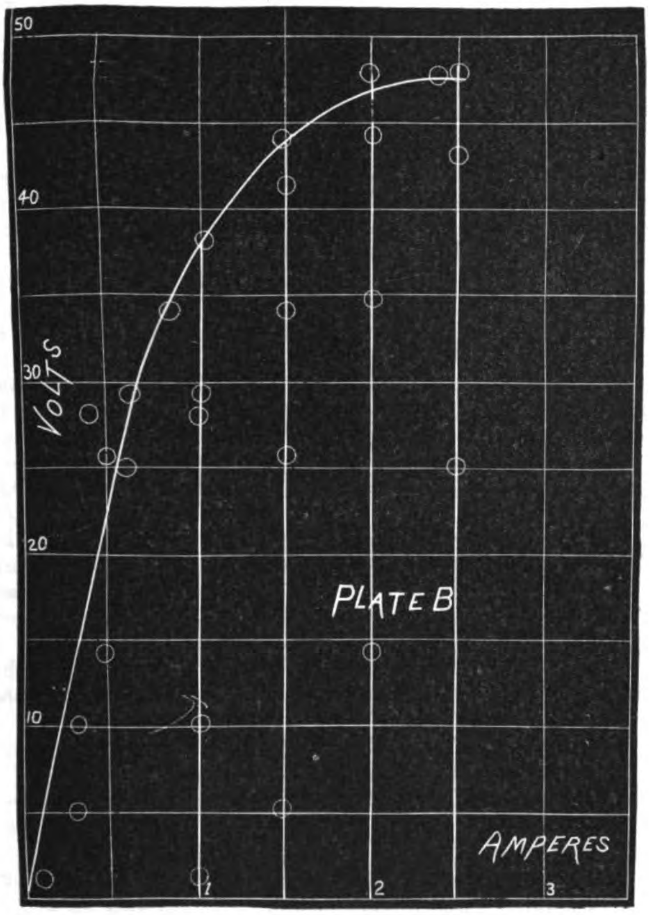
It will also be noticed that curves plotted between field current and E. M. F. from tables 2 to 6, coincide with the characteristic from table 1. This would necessarily be so, since in table 1 the external current is also the field current.

No higher E. M. F. can be reached on the constant current curve than that obtained from the machine worked as an ordinary series dynamo, the limit being reached as soon as the iron of the field magnets becomes saturated.

The horizontal distance between corresponding points on the constant current curve and on the curve of E. M. F. with field current, measures the amount of current flowing in the third brush line at that point, and also shows whether it is positive or negative.

It is evident that the point of crossing of the two characteristics—that is, the point at which the current in the third brush line becomes zero, will depend upon the *amount* of the constant current in the external circuit. Tables 11 to 14 give the data obtained when the external current was held respectively at 1.0, 1.5, 2.0 and 2.5 amperes. The points obtained by plotting field current with E. M. F. fall, as before, upon a common curve, as shown in plate B, and the constant current curves for 1.0, 1.5, 2.0 and 2.5 amperes cross this curve at 38, 44, 47 and 47.5 volts E. M. F. A curve for .5 of an ampere would cross the characteristic at about 22 volts.

Below the saturation point of the iron, the relation between current in the third brush line and E. M. F. is one of direct proportion. When the saturation point is reached, current in the third brush circuit may increase indefinitely without increase of E. M. F.



No very large *negative* current is obtained in the third brush line until the third brush is 90° or more in advance of the positive. This would seem to indicate that the constant-current characteristic cannot be carried much, if any, above the regular series characteristic unless the third brush has a very large lead, and this is objectionable because of very bad sparking at the third brush.

This arrangement is in reality equivalent to a compound wound dynamo in which one set of field coils is made to carry the current for both the series and shunt coils of the usual type of compound wound machine. Referring to diagram i, and the last line of table 4, it is clear that the field coils act as *series* coils in carrying a current of 1.70 amperes from P, the positive brush, around the external circuit to the negative brush, N, and that at the same time, they act as *shunt* coils in carrying .65 of an ampere from P, around the field magnets and back to T, the third brush. There is, however, this further distinction to be made between this arrangement and the usual type of compound dynamo,—that that part of the field current which partakes of the character of a shunt becomes zero under certain conditions of the external circuit, and that beyond this point the shunt circuit acts as a differential coil wound upon the field magnets. This is effected, not by an opposing current being sent around the field, but by the shunt becoming a *shunt around the series field coils*, thus depriving them of a part of the current they would otherwise receive, and so weakening the field. This is shown by the first line of table 4, where, of the 1.70 amperes in the external circuit the field coils carry but .35, while a current of 1.35 amperes is shunted around the field by the third brush line and added to the current in the main circuit. Though common enough in motors, the writer is not aware of any other case in which a differential coil or anything analogous to it is applied to a generator.

The arrangement then embodies at once the principles of three distinct types of dynamos, the type used being determined solely by the resistance of the circuit if the external current be kept constant. In keeping a constant external current, however, the resistance of the series field changes.

These three types are :—

1. Series dynamo + differential shunt coils (or rather what has the same effect as differential shunt coils).

This type is brought into use when the third brush is at a higher potential than the junction of the third brush line with the main line and a portion of the total current of the armature is diverted from the field coils, decreasing the strength of field.

2. Plain series dynamo.

This is the type made use of when both ends of the third brush line are at the same potential and the current flowing in it is *nil*, which occurs at the point of intersection of the two characteristics.

3. Series dynamo + cumulative shunt coils.

This occurs when the junction of the third brush line with the main line is at a higher potential than the third brush and current flows into the armature at the third brush.

It should be noticed that in this combination the total resistance of what corresponds to the shunt circuit of the field, including the resistance of the field coils and whatever resistance may be placed between the third brush line and the field line, is a constant, while the resistance of what corresponds to the series circuit of the field is variable, being changed by the movement of the finger, *f*, diagram i, along the resistance, *A B*.

The requirements for constant potential regulation are radically different from those necessary for constant current. Recurring again to Professor S. P. Thompson's fundamental equation of the dynamo,

$$E = 4\,n\,A\,H,$$

where n and A are both constant, it is evident that if E is to be a constant, H must also be a constant. Hence, for constant potential regulation the exciting current of the field coils must be a constant.

It is believed that the method here described for obtaining this result has not before been applied for this purpose. The arrangement is a very simple one, as shown in diagram ii. The third brush line passes through a low resistance and is joined to the main line at the positive terminal of the machine,—just outside the field coils. In this case either no resistance or a very low one is placed between the third and positive brushes, and no automatic arrangement is necessary, as the point of junction is a fixed one. Diagram iii shows the connections as used in the experimental work.

The effect of using different resistances in the third brush line is shown by tables 15 to 19, and curves 1 to 5, plate C, plotted from these tables. The third brush remained fixed at 36° in advance of the positive brush, this being given as before, 12° lead. Curve 6, of the same plate is plotted from table 20, and is the characteristic of the machine run as a series dynamo, reduced to the same speed as tables 15 to 19.

TABLE 20.

Volts.	Amperes.
8	.20
37.3	.88
48.2	1.48
51.6	2.22
53.5	3.06
56.2	4.53
59.0	5.83
57.2	6.50

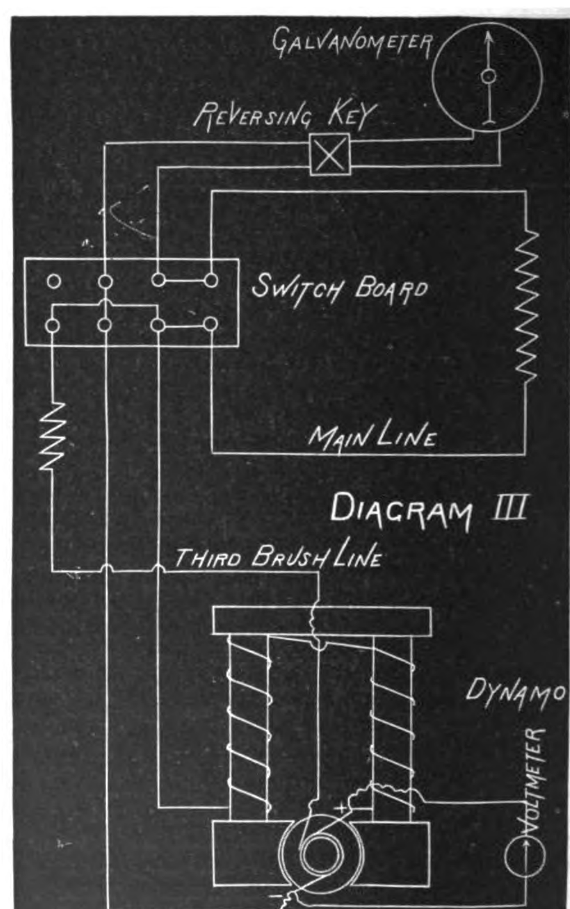
Curves 7 to 11 of plate c, are plotted from tables 15 to 19 with external resistances as abscissæ, and current in the third brush line as ordinates, and correspond respectively to curves 1 to 5. Negative current is plotted below the axis of X and positive current above.

	Volts.	Amperes in main line.	Amperes in field line.	Amperes in third Br. line.	Ohms in main line.	Ohms in third Br. line.	Angular advance of third Brush.
Table 15.	59.	.63	3.37	-2.74	80	Only the lead wire.	36°
	59.	.84	3.40	-2.56	60		
	59.	1.14	3.42	-2.28	50		
	59.	1.29	3.31	-2.03	40		
	58.	1.64	3.16	-1.52	30		
	57.5	2.00	3.12	-1.12	25		
	56.4	2.44	3.01	-.57	20		
	53.5	3.10	2.78	.32	15		
	50.	4.00	2.12	1.88	10		
	46.4	4.87	1.64	3.23	7.5		
Table 16.	57.	.68	2.95	-2.27	80	1	36°
	57.	.87	2.93	-2.06	60		
	57.	1.04	2.89	-1.85	50		
	56.5	1.24	2.88	-1.64	40		
	55.8	1.66	2.84	-1.18	30		
	55.2	1.96	2.86	-.90	25		
	54.8	2.40	2.86	-.46	20		
	53.5	3.08	2.80	.27	15		
	51.	4.40	2.83	1.57	10		
	48.5	5.40	2.82	2.58	7.5		
Table 17.	54.	.60	2.23	-1.63	80	2	36°
	54.	.81	2.30	-1.49	60		
	54.	1.01	2.32	-1.31	50		
	54.	1.19	2.37	-1.18	40		
	54.	1.55	2.46	-.91	30		
	54.	1.91	2.56	-.65	25		
	54.	2.37	2.69	-.32	20		
	53.5	3.09	2.89	.20	15		
	53.	4.40	3.33	1.07	10		
	52.	5.58	3.75	1.83	7.5		
Table 18.	52.5	.61	1.79	-1.18	80	3	36°
	52.5	.79	1.90	-1.11	60		
	52.5	.97	1.97	-1.00	50		
	52.5	1.17	2.05	-.88	40		
	52.5	1.55	2.19	-.64	30		
	52.5	1.90	2.37	-.47	25		
	53.	2.35	2.60	-.25	20		
	53.5	3.06	2.86	.20	15		
	53.	4.40	3.59	.81	10		
	52.5	5.52	4.22	1.30	7.5		
Table 19.	47.	.57	.91	-.34	80	5	36°
	48.5	.73	1.10	-.37	60		
	49.	.96	1.31	-.35	50		
	50.	1.17	1.53	-.36	40		
	51.2	1.53	1.80	-.27	30		
	52.0	1.88	2.11	-.23	25		
	52.8	2.28	2.40	-.12	20		
	53.5	3.06	2.96	.10	15		
	53.5	4.42	4.08	.34	10		
	52.3	5.46	4.88	.58	7.5		

These curves and tables show: (1) that the current in the third brush line is, at first, with high external resistances, negative, having its highest value when the external resistance is infinite or when the main line circuit is open; that with decreasing external resistances it gradually decreases, passes through zero, and again rises in the opposite direction; (2) that the point at which the third brush current becomes zero is independent of the resistance in the third brush line, becoming zero in each curve at exactly the same external resistance, and that this zero point is the point at which the new curve crosses the series characteristic; (3) that increase of resistance in the third brush line reduces the regulating power of the third brush, the curve at the limit coinciding with curve 6; (4) that increase of resistance in the third brush line decreases the field current, and consequently the E. M. F., but that the external current is practically independent of the resistance in the third brush line; (5) that the most constant E. M. F. is produced when the third brush line has a resistance of about three ohms—in this case about twice that of the field coils. This resistance, however, will vary, not only with the resistance of the field coils, but also with the angular advance given to the third brush and with the amount of current necessary to produce saturation—that is, with the quality and quantity of iron in the cores.

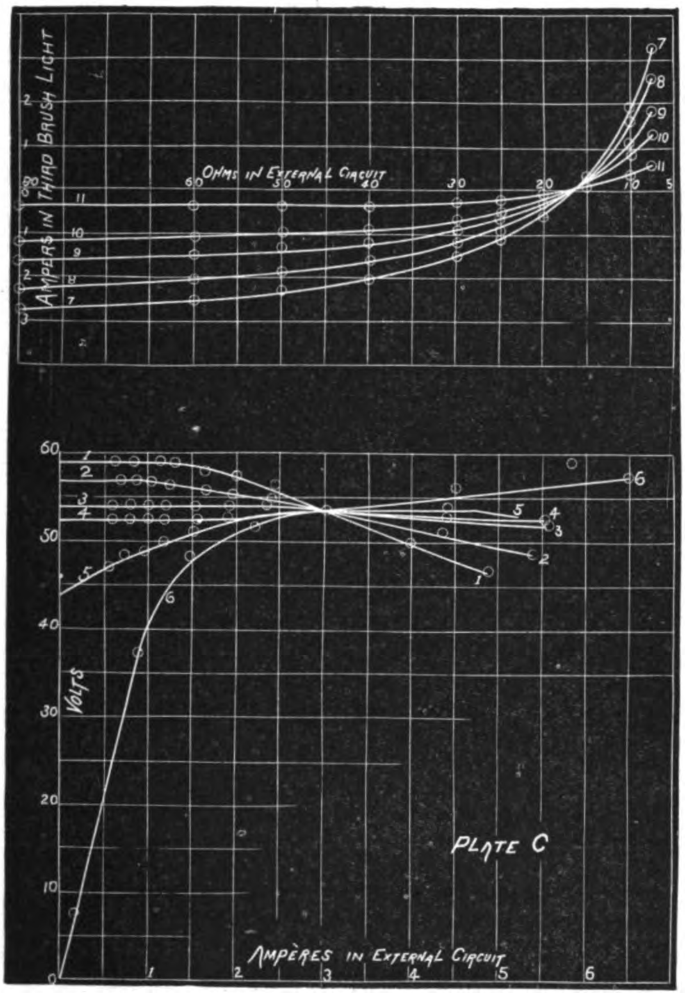
The explanation of these phenomena is slightly different from that already given for the changes observed in the case of constant current regulation. The same equation, however, is applicable. Using the same symbols, as before, equilibrium will exist between the ends of the third brush line, when $E_4 = E_1$, or $C' R' = 4 n H' A'$. In this arrangement R', which is here the resistance of the field coils only, remains a constant. A decrease of A' by bringing the third and positive brushes nearer each other, or, within certain limits, an increase of C', will make $E_4 > E_1$ and make the third brush positive. If now A' remains constant and C' be increased by a decrease of the external resistance, H' will increase in direct proportion as long as the iron of the field magnets is in the unsaturated condition, and there will be no change in the value of the equation, $E_4 = E_1$. But as soon as the saturation point is reached, H' becomes practically a constant, and further increase of C' will make $E_4 > E_1$ and the third brush positive. In tables 15 to 19 the field magnets are fully saturated when $E_4 = E_1$, and hence *any* increase of C' makes $E_4 > E_1$. Had A' been much smaller this result would not have been obtained.

The two opposite changes will make $E_4 < E_1$ and the third brush negative, viz: an increase of A_1' or a decrease



of C'. A decrease of C', however, will produce this result only when, as before, the iron is fully saturated. This is shown in the first part of table 19, where the field current was not sufficient to produce saturation of the magnets

and, as a result, the current in the third brush line remains practically unchanged while C' undergoes considerable variation.



It is evident that the potential of the two extremities of the third brush line is independent of the resistance of the line, and hence any variation in this resistance will have no effect upon the point at which its two ends will be at equal potential. It does, however, determine the amount of current flowing in this line, and hence the amount flowing in the field coils; since when the third brush is negative it adds its current to that of the field coils, and when it is positive the current in it is shunted *from* the field coils, as in the constant current regulation. This resistance must be low enough to allow of complete saturation of the field magnets.

Here, again, we have an arrangement which is in reality equivalent to a compound wound dynamo. Referring to diagram ii and the first line of table 17, it will be seen that the field coils perform the part of series coils in carrying .6 of an ampere from the positive brush, P, around the external circuit to N, and at the same time, as shunt coils, carry 1.63 amperes from P around the field magnets to T, the third brush. The same three types of dynamos are here brought into use, viz:—

1. Series dynamo+cumulative shunt coils.
2. Plain series dynamo.
3. Series dynamo+"differential shunt" coils, and the conditions under which each is brought into use are precisely like those already met with in regulation for constant current.

As was pointed out in the discussion of the constant current regulation, the application of the third brush necessarily interferes with the symmetrical flow of current in the armature, those coils lying between the third and positive brushes carrying more or less than the other coils, according as the third brush is negative or positive. In properly constructed dynamos this should produce no detrimental effect. It should, however, be taken into account in dynamo design when computing the size of armature wire from the amount of current it is to carry, for it is evident that in this case one-half the total current in the external circuit is not the maximum current which the armature coils must carry. A similar remark applies to the size of wire for the field coils.

A decrease of the resistance of the field coils would decrease the loss of potential between the positive brush, P, diagram ii, and the point B, and, the potential of T remaining constant, would increase the negative current in B T, and, other things being the same, the lower the resistance of the field the lower the resistance of the external circuit must be made before B and T are brought to the same potential, or in other words, before the new characteristic crosses the series characteristic; and if this point is not reached within the limits of the machine only the first of the three types of dynamos mentioned above is made use of. The same effect is produced by giving increased advance to the third brush, thus lowering its potential. Increased resistance of the field or decreased advance of the third brush will produce opposite effects. It will be found that whatever the field resistance or the advance of the third brush, there will be a corresponding resistance for the third brush line (and this in conjunction with the field coils may be regarded as the shunt circuit of a compound dynamo), for which the machine will produce a constant E. M. F.

Professor S. P. Thompson has observed that the efficiency of any compound wound dynamo for constant E. M. F. is very nearly a constant. Using his equation for efficiency, this is very nearly obtained from table 19 and curve 5, plate C, and this is probably very near the true curve for constant E. M. F. at the *terminals* of the machine, the volts here being the difference of potential between the brushes.

It is hoped that at some future time an experimental study, similar to that described above, may be made of third brush regulation for electric motors for both constant current and constant potential circuits. The field is an inviting one, and cannot fail to be productive of useful and practical results.[1]

BOSTON, Mass., Nov. 17, 1888.

A POCKET GALVANOMETER.[1]

BY AIKITU TANAKADATE.

(Assistant to the Professor of Physics, Imperial University, Tokio, Japan.)

(*Concluded from page 520.*)

§ II. FLAT COIL POCKET GALVANOMETER.

I NOW pass to the description of the flat coil pocket galvanometer, which may in virtue of its compactness and simplicity of construction be found useful for some purposes, although it can not, of course, take the place of circular coils when absolute determinations of electro-magnetic constants are required. One such instrument is represented in figure 8. It is essentially the same as an old form of current detectors, constructed, however, with due regard to the proportional dimensions which theory shows to be best.

The following calculation of the proper distance between two rectangular coils is made not so much for the sake of the flat coil galvanometer as for the sake of the internal coil mentioned above (page 517) and described in detail below (page 568).

1. See U. S. Patent Specifications Nos. 387,194 and 387,195, of July 31, 1888.

1. From the Journal of the Science College, Imperial University, Japan Vol. I.

Let $2a$ be the distance between the two coils.
" $2b$ " height of the coils.
" $2c$ " length "

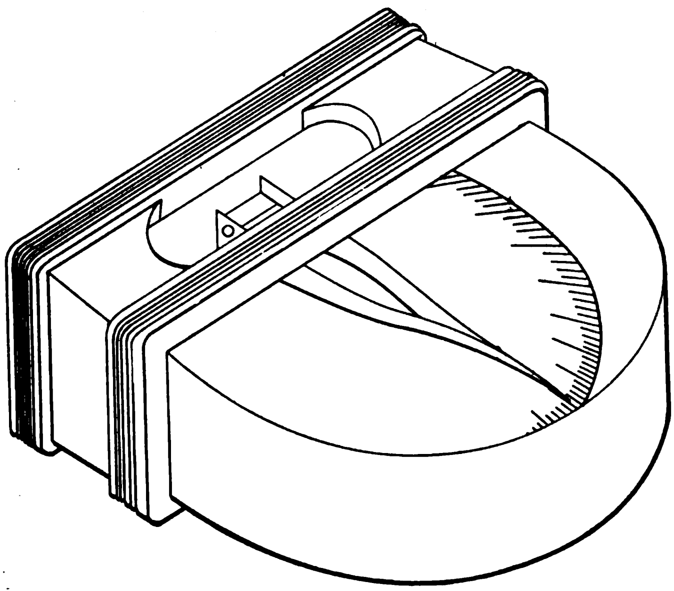


Fig. 8.

Let x, y, z, be the co-ordinates of any point referred to the centre of the coils as origin, axes being parallel to a, b, c.

Let ξ, η, ζ be the co-ordinates of any corner of the coils referred to any point x, y, z as origin, so that

$$\xi + x = a, \qquad \eta + y = b, \qquad \zeta + z = c.$$

Then the potential at any point due to unit current is the sum of the solid angles subtended by the coils, or

$$V = \Sigma \sin^{-1} \frac{\eta \zeta}{\sqrt{\xi^2 + \eta^2} \sqrt{\xi^2 + \zeta^2}} = \Sigma\, \Omega \text{ say}$$

Σ meaning the summation for eight corners, there being four to each coil. Now,

$$\frac{\delta^n}{\delta x^n} = (-1)^n \frac{\delta^n}{\delta \xi^n}; \quad \frac{\delta^n}{\delta y^n} = (-)^n \frac{\delta^n}{\delta \eta^n}; \quad \frac{\delta^n}{\delta z^n} = (-1)^n \frac{\delta^n}{\delta \zeta^n}.$$

Hence,
$$F = -\frac{\delta V}{\delta x} = \Sigma \frac{-\eta \zeta}{\rho_0} \left(\frac{1}{\rho_1^2} + \frac{1}{\rho_2^2} \right)$$

where $\rho_0 = \sqrt{\xi^2 + \eta^2 + \zeta^2}$; $\rho_1 = \sqrt{\xi^2 + \eta^2}$;
$\rho_2 = \sqrt{\xi^2 + \zeta^2}$

The force at the centre of the coils will be given by making $\xi, \eta, \zeta = a, b, c$ respectively and multiplying the result by n, if n be the number of turns of wire in the coil.

The increment of force at any displaced point δx, δy, δz, is given by the equation (odd terms disappearing as before),

$$\Delta^2 F = \frac{1}{\underline{|2}} \left\{ \frac{\delta^2 F}{\delta x^2} (\delta x)^2 + \frac{\delta^2 F}{\delta y^2} (\delta y^2 + \frac{\delta^2 F}{\delta z^2} (\delta z^2 \right\} + \frac{1}{\underline{|4}} \left\{ \cdots\cdots\cdots \right.$$

but, since

$$\frac{\delta}{\delta x} \Delta^2 V = \frac{\delta^2}{\delta x^2} \frac{\delta V}{\delta x} + \frac{\delta^2}{\delta y^2} \frac{\delta V}{\delta x} + \frac{\delta^2}{\delta z^2} \frac{\delta V}{\delta x} = 0$$

it is necessary and sufficient that any two of $\delta^2 F / \delta x^2$, $\delta^2 F/\delta y^2$, $\delta^2 F/\delta z^2$ should vanish simultaneously, in order that they all may vanish at the same time.

Thus we have

$$\frac{\delta^2 F}{\delta y^2} = \Sigma \frac{\eta \zeta}{\rho_0} \left\{ \frac{3}{\rho_0^2} \left(1 - \frac{\eta^2}{\rho_0^2}\right) \left(\frac{1}{\rho_1^2} + \frac{1}{\rho_2^2}\right) + \right.$$

$$\frac{\delta^2 F}{\delta z^2} = \Sigma \frac{\eta \zeta}{\rho_0} \left\{ \frac{3}{\rho_0^2} \left(1 - \frac{\zeta^2}{\rho_0^2}\right) \left(\frac{1}{\rho_1^2} + \frac{1}{\rho_2^2}\right) + \right.$$

$$\left.\begin{array}{l} \left. \dfrac{6}{\rho_1^4} - \dfrac{4\eta^2}{\rho_0^2 \rho_1^4} - \dfrac{8\eta^2}{\rho_1^6} \right\} = 0 \\ \left. \dfrac{6}{\rho_2^4} - \dfrac{4\zeta^2}{\rho_0^2 \rho_2^4} - \dfrac{8\zeta^2}{\rho_2^6} \right\} = 0 \end{array}\right\} \text{(A)}$$

which at the centre of the coils (ξ, r, ζ being a, b, c) reduces to

$$\frac{\delta^2 F}{\delta y^2} = \frac{b c}{(a^4 + b^2 + c^2)^{\frac{5}{2}} (a^2 + b^2)^3} \left\{ 12 a^6 + (21 b^2 + 15 c^2) a^1 + (6 [b^2 + c^2]^2 - 2b^2 c^2) a^2 - b^2 (b^2 + c^2)(3b^2 + 2c^2) \right\} = 0$$

$$\frac{\delta^2 F}{\delta z^2} = \frac{b c}{(a^2 + b^2 + c^2)^{\frac{5}{2}} (a^2 + c^2)^3} \left\{ 12 a^6 + (21 c^2 + 15 b^2) a^4 + (6 [b^2 + c^2]^2 - 2b^2 c^2) a^2 - c^2 (b^2 + c^2) (3c^2 + 2b^2) \right\} = 0$$

Unless these two equations are simultaneously satisfied, the three partial differential coefficients will not vanish. Eliminating a between the two equations we find that the only admissible cases are when $b = c$, and either b or $c = \infty$. Thus it seems that $\Delta^2 F$ can not be made to vanish entirely except for the case of a square, and four infinite parallel straight currents. But when either b or c is great compared with the other, the partial differential coefficient with respect to the greater will be comparatively small as may be judged from the equations (A). Hence for such cases, if $\delta^2 F / \delta^2 x = 0$, both the others must be small.

But since $\dfrac{\delta^2 F}{\delta x^2} = -\left(\dfrac{\delta^2 F}{\delta y^2} + \dfrac{\delta^2 F}{\delta z^2}\right)$* we find from the above two equations

$$\begin{aligned} \frac{\delta^2 F}{\delta x^2} \propto 24a^{12} &+ 72 (b^2 + c^2) a^{10} + [93 (b^4 + c^4) + 146 b^2 c^2] a^8 \\ &+ 8 (b^2 + c^2) [9 (b^4 + c^4) + 4b^2 c^2] a^6 \\ &+ 3 (b^2 + c^2)^2 [11 (b^4 + c^4) - 10b^2 c^2] a^4 \\ &+ 2 (b^2 + c^2)^2 [3 (b^4 + c^4) - 7b^2 c^2] a^2 \\ &- b^2 c^2 (b^2 + c^2)^2 [2 (b^4 + c^4) + b^2 c^2)] = 0 \end{aligned}$$

from which a is to be found for any given value of b and c, the sides of the coils. Since the equation is homogeneous, we may take either b or c as unit of length and measure the other lengths in terms of it. Thus, if we take b (half the height of the coils) as the unit, and express a and c in terms of it, we have all the possible cases brought out by varying c from 1 to ∞. Examining the above equation, we find that there is only one variation of sign among the coefficients of a whatever b or c may be. Hence this equation has only one pair of real roots.

Putting $a = \dfrac{1}{\sqrt{2}} b$, and $a = \dfrac{1}{2} b$ successively the expression changes sign once, so that the positive root of this equation lies between .5 and .71 whatever be the values of c/b. Dividing the equation by its last term we see that

* The equation $\delta^2 F/\delta y^2 + \delta^2 F/\delta z^2 = 0$ shows that at the origin F, considered as a function of y and z, is a minimax with respect to those variables; when $b = c$, this becomes what may be called a *flat point*, and for $b = \infty$, a *flat line*.

the higher powers of a rapidly converge when c increases. When $c = \infty$ the equation reduces to

$$3a^2 - b^2 = 0$$

which agrees with the previous result. When $b = c = 1$ it reduces to

$$4\,(a^2 + 1)^3\, 6a^6 + 18a^4 + 11a^2 - 5) = 0$$

as might be found by an independent calculation.

Since a knowledge of the solution of this equation will serve as a guide in the construction of such galvanometers, I give the following table of its roots for several values of c/b together with the values of the field and the proportional decrement of force at the point $\delta x = \frac{1}{2} a$. From these numbers we can at once judge of the uniformity of the field.

Value of c/b.	a (root).	$2\tan^{-1}\frac{a}{b}$.	$F_0 - \frac{8bc}{r_0}\left(\frac{1}{r_1^3} + \frac{1}{r_2^3}\right)$	$\Delta^2 F/F_0$ at $x - \frac{1}{2}a$.
1	.54451	57° 8′	8.144	.00085
$\sqrt{2} - 1.4$	.60040	61° 58′	7.151	.00081
2	.59786	61° 42′	6.681	.00077
3	.58898	60° 34′	6.365	.00074
4	.57980	60° 13′	6.232	.00074
5	.57843	60° 6′	6.148	.00074
10	.57742	60° 0′	6.089	.00074
∞	.57735	60° 0′	6.000	.00075*

* For Helmholtz's arrangement $\Delta^2 F/F_0 - .00077$.

The values of F_0 for any actual case are to be obtained by dividing the above number by the number expressing half the height of the coils in centimeters, and multiplying by the number of turns of wire in the coil. From the table it is seen that when the length, c, exceeds 5 times the height b, the action of the coils is not far from that of the four infinite parallel currents already treated. This justifies the experiment described at the close of the first section of the paper. Further, we see that *the assumption for a large magnetic shell made in the beginning of the paper is practically correct*, if the straight part of the circuit extends more than 5 times the distance between the upper and lower magnets ($c/b = 10$) on each side of the instrument, and if the length of each magnet is not less than $5c$.

In practice, however, the coils are of finite section whereas the above results refer to coils of infinitesimally small section. So long as the depth and width of the sections of the coils are small fractions (say 1/10) of the height of the coils or of their distance apart, we may, without sensible error take the centres of the sections for the positions of simple equivalent coils of infinitesimal section.

If the depth of the section is small and the width finite, the force at the centre of the coils is got by a process of ordinary integration. Thus if the number of turns of wire per centimeter be n, we have with the same notation as before,

$$F = \Sigma \int_{a_1}^{a_2} \frac{\delta \Omega}{\delta x}\, n\, dx$$

$$= \Sigma\, n \Big[\, \Omega \,\Big]_{a_1}^{a_2}$$

when a_1 and a_2 are the distances of the internal and external faces of either coil measured from the point half way between the two coils. Hence in order that the effect of eccentric displacement may be small, we have

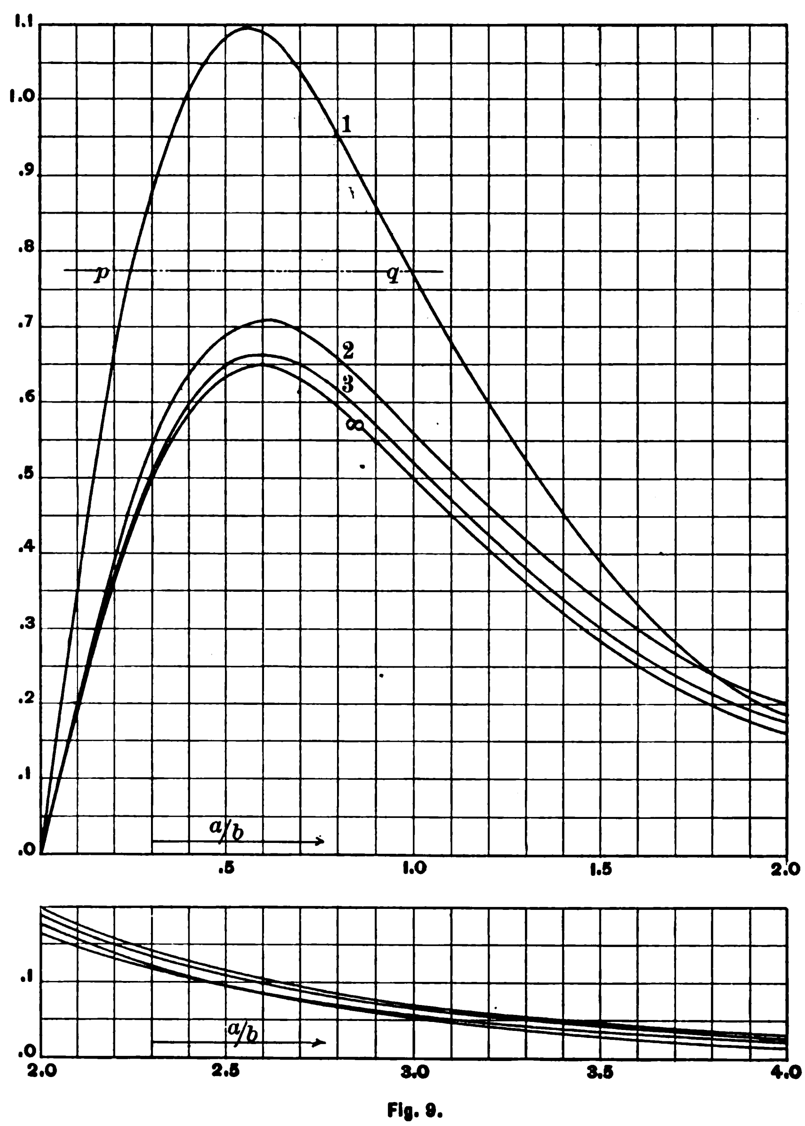


Fig. 9.

$$\frac{\delta^2 F}{\delta x^2} = \Sigma \left\{ \left(\frac{\delta^3 \Omega}{\delta x^3}\right)_{a_1} - \left(\frac{\delta^3 \Omega}{\delta x^3}\right)_{a_2} \right\} = 0$$

$$\frac{\delta^3 \Omega}{\delta x^3} = \frac{\delta^3}{\delta \xi^3} \sin^{-1} \frac{\eta \zeta}{\sqrt{\xi^2 + \eta^2}\ \sqrt{\xi^2 + \zeta^2}}$$

$$= \frac{\xi \eta \zeta}{\rho_0} \left\{ \frac{1}{\rho_0^2} \left(\frac{1}{\rho_1^2} + \frac{1}{\rho_2^2} \right) + 2 \left(\frac{1}{\rho_1^4} + \frac{1}{\rho_2^4} \right) \right\} \quad \text{(B)}$$

but we have seen that $\frac{\delta}{\delta x}\frac{\delta^2\Omega}{\delta x^2}$ vanishes for some value of a/b between .5 and .71 so that $\frac{\delta^2\Omega}{\delta x^2}$ has a maximum between $a/b = .5$ and .71 for any ratio of c/b. Hence, $\delta^2 F/\delta x^2$ can always be made to vanish by taking a_1 and a_2 on both sides of the maximum. The values of $\frac{\delta^2\Omega}{\delta x^2}$ are graphically represented in figure 9, for $c/b = 1, 2, 3, \infty$.

At first these curves are in the order 1, 2, 3, &c., counting from above, but afterwards when they become distinctly asymptotic their order becomes reversed. This is indeed apparent from the equation.

An indefinite number of proper values for a_1 and a_2 may be got by the following simple construction. Draw any horizontal line cutting any particular curve in the points p, q; the x co-ordinates of these points at once give a special pair of suitable values, a_1 and a_2. In the case of simple coils, p and q coincide at the top of the curve, which is the case already discussed.

§ III. INTERNAL COILS FOR MEASURING LARGE DIFFERENCES OF POTENTIAL AND SMALL CURRENTS.

We are now in position to consider the dimensions which ought to be given to the internal coils spoken of in page 517 as necessary for the measurement of large differences of potential and small currents. For examining the above curves we see that $\delta^2\Omega/\delta x^2$ becomes very small when a/b is more than 3. Also putting (B) in the form

$$\frac{\delta^2\Omega}{\delta x^2} = \frac{\xi\,\eta\,\zeta}{\rho_0\,\rho_1^2}\left(\frac{1}{\rho_0^2}+\frac{2}{\rho_1}\right)+\frac{\xi\,\eta\,\zeta}{\rho_0\,\rho_2^2}\left(\frac{1}{\rho_0^2}+\frac{2}{\rho_2^2}\right)$$

and considering η and ζ as variables we may regard the action as due to two equivalent "electro-magnetic strips."* The coils are shown in the diagram below. There are four, one around each magnet. They are necessarily made of small height, in fact just enough to allow the wire magnets to move freely inside and yet to leave a good space for the jaw. For convenience of reference call these coils A, B, C, D, as indicated in the figure. From the symmetry of configuration we may take any one of the eight poles and consider the action of four coils upon it. Take one of the poles inside A and call it P_A for the sake of definiteness. The variations in the actions of C and D upon P_A, due to possible motions of the same, may be regarded as the differentials of the actions of electro-magnetic strips placed along the edges of C and D. These we may safely neglect in comparison with the variations in the actions of A and B. Thus we have only to consider the effect of the four faces of A and B. But since each coil extends a good way over the poles of the magnet, we may regard these coils as drawn out indefinitely in the direction of the magnets' axes without committing any sensible error as was shown in the last section. Hence, calling the distances of the faces of A and B from P_A, a_1, a_2, a_3, a_4, as in the diagram, we have

$$\Delta^2 F = \left(\frac{\delta^2\Omega}{\delta x^2}\right)_{a_1} + \left(\frac{\delta^2\Omega}{\delta x^2}\right)_{a_2} - \left(\frac{\delta^2\Omega}{\delta x^2}\right)_{a_3} + \left(\frac{\delta^2\Omega}{\delta x^2}\right)_{a_4} \quad \text{(C)}$$

where $a_4 = a_1 + a_2 + a_3$ from symmetry of arrangement. But from the curves given above we see that when a/b is more than 4, the values of $\frac{\delta^2\Omega}{\delta x^2}$ become insensible. Therefore by simply extending the ends of the coils so as to have the least value of a/b more than 4, we make $\Delta^2 F$ practically vanish.

* See my paper on the "Electro-magnetic Declinometer" published in the Proceedings of the Royal Society of Edinburgh (vol. xii. p. 544, 1883-4) or Rigakukyokwai Zassi (vol. ii, p. 84), in which curves are shown very similar to those just given.

Theoretically there is an indefinite number of solutions of the equation (C) obtained by selecting sets of values of a_1, a_2, a_3, a_4, such that

$$\left(\frac{\delta^2\Omega}{\delta x^2}\right)_{a_1} + \left(\frac{\delta^2\Omega}{\delta x^2}\right)_{a_2} + \left(\frac{\delta^2\Omega}{\delta x^2}\right)_{a_4} = \left(\frac{\delta^2\Omega}{\delta x^2}\right)_{a_3}$$

which is always possible since the curve has a maximum. But to apply such a mode of solution practically is dangerous on account of the steep rise of the curve toward the maximum. Any small errors in the values of a_1, a_2, &c., will give rise to an ultimate error greater than that caused by the neglect of the converging terms when a/b is made

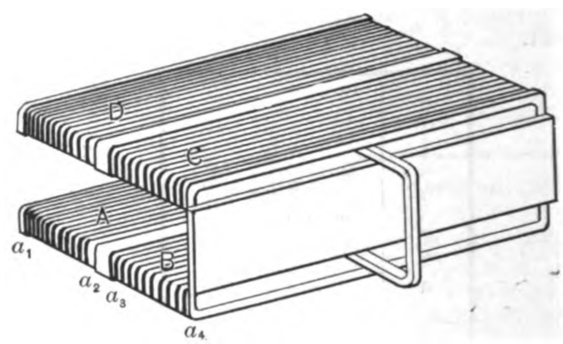


Fig. 10.

great. Hence, in practice it is advisable to make $a/b > 4$, and limit the range of deflection so that the least value of ξ/b should not fall within 2 or 3. If the instrument were constructed on a large scale with all the dimensions determined accurately, the graphical solution just indicated might be applicable.

Figure 10 above shows the actual coil belonging to the instrument represented in figure 4, which was purposely drawn without the coil so as to lay open its internal construction. Both these figures are drawn very nearly to full size. The central ridges which divide the upper and the lower coils into two parts serve for holding the pivots of the frame of the magnets.

The fittings of the levers and springs remain, of course, exactly the same as in figure 4.

The coil is wound with a thin copper wire in four layers and has a resistance of 40 ohms. An extra resistance of 5,000 ohms is added by introducing a small bobbin of fine german-silver wire (not shown in figure 1) into the back corner of the case of the instrument. The connection of the terminals is diagrammatically shown in figure 11.

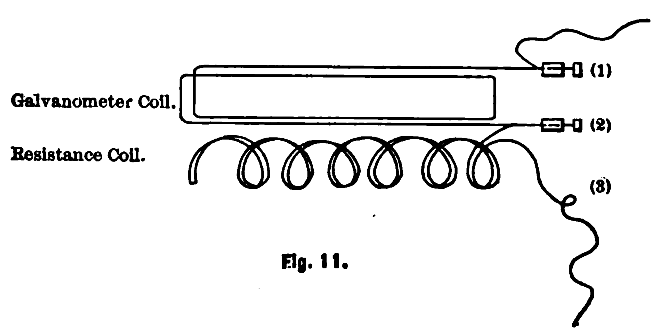


Fig. 11.

For the measurement of potential differences, the terminals (1) and (3) are used and for the measurement of small currents the terminals (1) and (2). To avoid the possibility of confusion as to which pair of terminals is to be used, a pair of binding screws are provided at (1) and (2) for the case of small currents, and a pair of wire ropes at (1) and (3) for the case of potential differences. An alternative construction would be to omit the pair of binding screws and provide a plug-hole between (2) and (3) to shunt off the resistance when the instrument is to be used for small currents. For the measurement of very

large potential differences or of moderate currents, a system of shunts may be employed in the usual way. Various other like devices may be multiplied almost endlessly.

A separate calibration is required for this coil, but this is nothing more than the ordinary galvanometer gauging. The following table gives a comparison of the readings of an actual instrument with those of a standard galvanometer:—

Standard galvanometer.		Pocket galvanometer.	
Reading.	Reduced to amperes.	Reading.	Value of 1 division in amperes.
7.8	.02278	25.8	.000883
13.6	.03971	45.1	.000880
22.1	.06453	73.2	.000882
		Mean	.000882

From the above result we easily find, for the given extra resistance of 5,000 ohms inserted, the value of the potential difference corresponding to 1 division of the scale. It is 4.4 volts (= .000882 × 5040). If a thinner wire be wound with a greater number of layers, it will be easy to make the above value 1 volt or less. Indeed this would have been done in the instrument now being described had it not been at the time impossible to obtain in this country a fine enough insulated copper wire. No doubt, the value required could be arrived at by simply reducing the resistance to little more than 1,000 ohms. This however would be too small for the purpose; if possible 10,000* ohms or more would be desirable.

§ IV. EXTERNAL COIL.

A single rectangular coil consisting of several hundred turns of a fine copper wire (see figure 12) may take the place of this internal coil just described, if one part of the coil be temporarily slipped in between the jaw in the same way as the so-called ribbon was slipped in when the instrument was being gauged. In simplicity of construction, this plan is perhaps superior to that of introducing the internal coil, especially when the instrument is to be made on a small scale. But it is inferior inasmuch as it needs an extra piece of apparatus.

Of course, we cannot regard this coil as equivalent to a single magnetic shell of an infinite extent. But referring to the diagram of the field of force given in figure 6, and the table of page 567, we see that the variation of the action of the coil due to deflections of the magnet will be insensible, if the height of the coil be such that the part outside the jaw is just below the base of the instrument, and if the length of the coil be such that the bends are distant from the nearest poles of the magnets by more than five times the distance between the magnets.

Further, we see that the part of the coil outside the jaw will add to the effect of the part inside by about 33 per cent., the current necessarily being in oppposite directions in these two parts.

The coil shown in figure 12 has 600 turns of copper wire and a resistance of 100 ohms.

Comparison with a standard galvanometer gave the following results:—

Standard galvanometer.		Pocket galvanometer.	
Reading.	Reduced to amperes.	Reading.	Value of 1 division in amperes.
11.8	.03446	41.2	.000836
17.4	.05081	61.0	.000833
21.2	.06190	74.5	.000831
		Mean	.000833

* Thomson's graded potential galvanometer has about 7,000 ohms.

Hence, when an extra resistance of 5,000 ohms is added 1 division of the scale will correspond to 4.25 volts (= .000833 × 5100).

Thus we see that the present instrument measures from .001 amperes to 168 amperes and from 4 volts to 400 volts, with a probable error of 1 per cent. The galvanometer

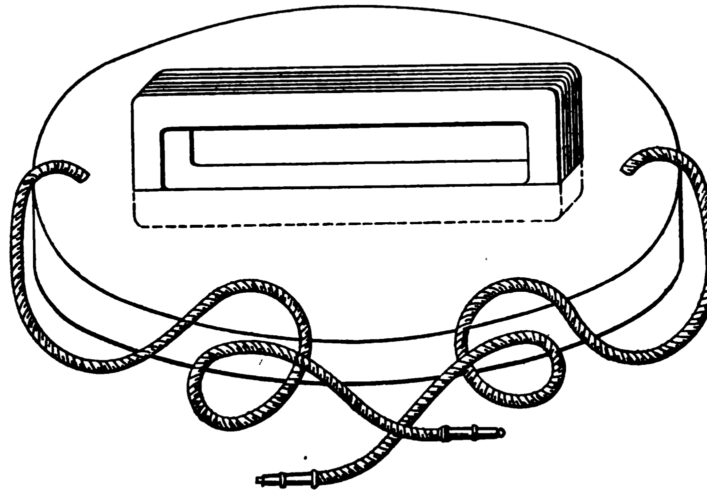


Fig. 12.

has, of course, three constants, one for the jaw, one for the internal coil, and one for the external coil if it has one. When these are once determined it is not necessary, however, to test all the three from time to time, since the ratios of the constants amongst themselves depend only upon the configuration of the instrument. These ratios being determined once for all, any change in the value of the constants, due to a change in the moments of the magnets or the strengths of springs, can be readily discovered by testing for any one of them, say, that for the internal coil.

PATENTS OUTSIDE THE COURTS.

BY GEORGE H. STOCKBRIDGE.

Is a patent a certificate of validity and value? If not, who is responsible? And how can the value of patent property be made more stable and certain?

An analysis of all adjudicated patents shows that seven out of every ten are sustained.[1] This settles the matter as to the *validity* of such patents as are brought to test in the courts. Moreover, it has been shown that the Patent Office is responsible for about two-thirds of the bad patents; and it has been suggested that a better showing, on the part of the Patent Office, would be made by bettering the conditions under which the work of the office is now done.[2]

In adding a final word to what has been said already, it is only fair to raise the question whether there are any considerations which affect the conclusions already drawn, or which serve to make the answers to our starting questions more complete. Are patents subjected to any tests outside the courts which affect their value as property? Or are the court records, for any reason, inconclusive as to the value of patents? This last point is exceedingly important as it touches a matter which is often overlooked, and yet which has everything to do with patents looked at from the standpoint of patent owners.

To begin with, then, the decisions of the courts serve to determine the one question of validity. Of course, if they deny that a patent is valid its fate is sealed once for all. But, on the other hand, a patent may be as strong as adamant, legally, and yet be a worthless piece of property, irrespective of the importance of the invention which it is

1. See the *Electrical World*, New York, April 30, 1887.
2. See the ELECTRICAL ENGINEER, October, 1888.

supposed to cover. Valid and valuable are two very different terms in the parlance of patents. A man may make an invention as important as the telephone and secure a valid patent on it, and yet hold a thing that would be dear at a quarter of a dollar, unless the parchment of the patent cover is at a premium.

To the initiated these things are already sufficiently familiar, but there are many others that ought to be initiated. The ordinary inventor holds that a patent issued on an invention is a patent which protects the invention, and it would be a good thing for him and for those with whom he deals, if they could learn the facts.

A patent which covers the mere structure, ingredients, or mode of operation set forth in the specification, generally represents money wasted. Every real invention is generic; that is, it represents an idea which is capable of different modes or forms of expression. And if my patent vests in me merely the exclusive right to the one form I have described, I have nothing of special value, unless, as may or may not happen, I have hit upon the only or the best practical embodiment of the idea. In making this statement I do not refer to new departures, like the phonograph, or the telephone, but I mean that this generic quality of invention extends to every detail and refinement of an art this side of perfection. In other words, every patentable invention is generic and may have a generic claim.

Now the courts are not called upon to decide whether a patent contains the broadest possible claim, but only to pass upon the claims actually contained in the patent document. Accordingly, it may easily happen that the records of an infringement proceeding will show that a patent was judicially sustained, whereas the scope of the patent may be so limited as to make it absolutely worthless.

But there is a tribunal which passes upon many such patents before they reach the courts. I allude to that class of cases which are adjudicated in lawyers' offices, and which never reach the courts at all. No one can do more than guess how large this class is, but my own recent experience and observation lead me to believe that it is larger than is usually supposed; certainly it is larger than I had supposed. In a patent practice of about four years' duration, some dozen of this class of patents have stuck in my own pigeon holes, that but for my advice, would be figuring in hopeless infringement suits. To that extent, then, the figures on the side of patents declared bad by judicial decision, have been reduced in a way that does not appear in the court records. Older attorneys must have contributed in far greater numbers to the reduction. There is a long list of patent attorneys, and, when the reports were all in, we might find a number of cases large enough to demand a considerable re-adjustment of our ratio of seven to three. How considerable, every one will have to estimate for himself. To some minds it will seem important enough to invalidate all conclusions based upon that ratio as a criterion for patents in general.

Now a patent lawyer or attorney who is called to pass upon patents in advance of the courts, finds just this difficulty most frequently; to wit, that the generic claim which ought to be there, is omitted. Sometimes these cases go beyond him, and, in spite of his advice, come up for a judgment in a higher tribunal. In a recent notable instance, familiar to electricians, a patent was thrown out in the courts because it did not cover the construction against which suit for infringement was brought. The inventor immediately applied to the Patent Office for a re-issue of his patent on the ground that he had intended to cover the construction referred to, but that, having been judicially informed that he had failed to cover it, he made application for a reissue to remedy the defect. By an oversight, the inventor in this instance secured his reissue; but how such reissue applications are treated generally, and properly, the public already knows.

A very common instance, however, is illustrated by the following: An inventor sees an unlicensed rival making and selling an invention which is a clear equivalent of one for which he has obtained a patent. "Bring suit," says he to his lawyer. "Well, but," "Well, but what?" urges the inventor. "The truth is, you have not got the claim you need for bringing suit." "But is not Smith making precisely what I invented and got a patent for?" "What you invented, certainly, but you unfortunately failed to obtain the claim that would have protected you." "Well, then, get me a reissue." "Let me see, this is November 22d, 1888, and your patent was issued November 23d, 1886. I am afraid we cannot get your reissue application into the office before the expiration of two years, and it will be of no use to apply for a reissue after that. Besides, a reissue with broadened claims stands little chance in the courts to-day." "But what have I done to forfeit my right to what I really invented?" "The courts say you have dedicated all but what you claim to the public. What you really did was to trust to an ignorant or incompetent or under-paid attorney. At least, I judge you had no actual intention of dedicating anything whatever to the public. But you have made a legal dedication and I cannot reclaim your property."

Here, now, is a deplorable state of things, and it is pertinent to ask, as before, who is responsible for it? If we can ascertain that, perhaps we can apply a corrective. And, doubtless, as before, the Patent Office, by ignorant or finical or obstinate rulings, contributes to the result. The main responsibility, however, is with the inventor or his attorney, and we who act in the latter capacity may as well take it upon ourselves. I have had occasion to remark, elsewhere, that a patent well drawn is a patent sustained. It may be added, here, that a patent well drawn is a generic, inclusive patent covering all the inventor has fairly invented and yet perfectly defensible in law. How few patents reach this standard not many of us would like to say.

From this point of view, it is easy to see that the judicial aspects of patents are, in themselves, among the least considerable to patent owners. The sustaining of a patent is of no use unless the patent itself is properly drawn. The best work (or the poorest) for the inventor is done by his solicitor, and not by his lawyers. Given a good patent, the labor of sustaining it is light; but a badly drawn patent is defeated already, if contested, and more than likely to be so worthless as to form no proper basis for a suit.

These are facts which it is proper that everybody should know. Were they more widely appreciated, they would exist less widely. In other words, the remedy would be applied, which, having gone thus far, I cannot omit to suggest. Inventors would employ intelligent attorneys and give them fees corresponding in some degree to the importance of the labors which they perform. So long as that is not the case, we shall continue to have the state of things set forth in the foregoing. The attorneys who are capable of giving legal opinions of weight will continue to shelve perhaps as many patents as the courts docket. With the prevailing fees, attorneys, no matter how intelligent, cannot do justice to their clients in patent cases. Every attorney knows this, and the best, or best established, of them come out openly and charge what their work is worth. There is a tendency upward in the fees of most of the best attorneys which the rest ought to uphold. It is the only way to improve the quality of patent work.

Under the British system, in the practical absence of rejections, the danger is that patents will be too broad. Before a patent is tested in the English courts, a solicitor commonly makes an exhaustive search (like one of our own validity searches mentioned above), for which, as is quite proper in view of the labor and responsibility involved, he charges a large fee. Under our system, the danger seems to be that the claims will be too narrow. Yet the decision of that point rests with the inventor's attorney, assuming that the examiner is competent and reasonable. But even under that assumption, what labor

is not involved in arguments, in compromises which shall not compromise, in appeals and petitions! All this can be so easily saved by concession, and yet concession means the loss of everything. It is true that an attorney who is conscientious or careful of his reputation will stand by, even if the pay be ridiculously small. But he will not choose to be caught a second time. The work of one of our attorneys is infinitely more important than that of those who make searches under the British system, for it involves the decision not only as to what form of claim is anticipated by the state of the art, but also what form can be sustained in view of it. The one creates the conditions by which the patent stands or falls, the other explores and reports on them. And yet what an insignificant sum the one receives, as compared with the other!

In a previous article, it was suggested that the way to improve the ratio of seven to three on adjudicated patents was to increase the room, force, and salaries in the Patent Office. To better the status of patents outside the courts, the patent fees, and consequently the time and labor devoted to each case, must be increased.

THE GEYER-BRISTOL METER FOR DIRECT AND ALTERNATING CURRENTS.[1]

BY PROFESSOR WILLIAM E. GEYER.

In the meter about to be described we make use of the heating effect of the current. Electric measuring instruments depending on this heat effect are not new. In the Cardew voltmeter we have an application which has found much favor. Here the current of greater or less strength traverses a long, thin wire, heats it more or less, and the direct expansion is a measure of the current, and indirectly of electromotive force.

In an ammeter it is necessary to keep down its resistance, and I therefore doubt whether direct expansion can be usefully applied for this purpose; for the actual elongation of a bar of metal even when raised through a considerable range of temperature is very small.

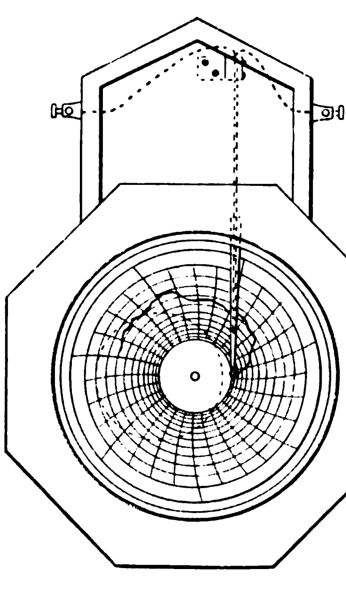


Fig. 1

In the familiar compound bar we have a case where a very small actual elongation produces a relatively very great lateral displacement.

I think I shall best be able to explain to you our meter, by recalling to your minds this old device. In the simplest compound bar two strips of metal which have different co-efficients of expansion are securely soldered flat wise along their entire length. Brass and steel are metals frequently taken. On heating, the brass expands more than the steel, and in consequence the bar bends, becoming convex on the side of the brass. When such a bar is heated by the passage of the electric current, it will deflect, and this deflection may be made a measure of the current. The disadvantage of such an instrument would be that atmospheric changes of temperature would also cause deflection, so that troublesome corrections would have to be introduced.

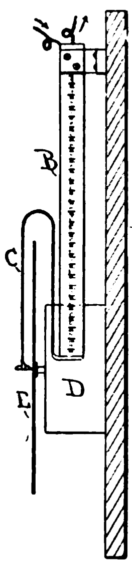


Fig. 2.

In our meter we also use a sort of compound bar, but eliminate at once the effect of surrounding temperature by taking metals whose co-efficients of expansion are the same or sensibly equal; in fact we take the same metal. Our first form of construction was as follows: A wire of german silver is laid upon a strip of german silver of considerably greater cross-section and radiating surface. The wire and strip are soldered together at one end, separated for the remainder of the length by a film of mica, then tie together at frequent intervals with silk or other insulating material, and suitably supported or clamped at the unsoldered end. If now a current, either continuous or alternating, is allowed to enter the strip at one end, it runs along its length, there enters the wire and leaves the instrument from the other end of the wire.

For a given current in the wire, on account of its greater resistance and also on account of its smaller radiating surface, the wire becomes hotter than the strip. In consequence of the difference of expansion, the bar bends, becoming convex on the side of the smaller conductor. This combination we call a differential bar.

We would also state that inasmuch as the results obtained by the use of this instrument are due to the excess of the heating effect of an electric current upon one portion of the bar or its equivalent over the other, it is in a measure immaterial to the principle of the invention whether the current which produces the differences in temperature be caused to heat the two parts directly or indirectly. For example, the more expansible part, in lieu of being included directly in the circuit, may be arranged in close proximity to, but insulated from, a wire or conductor which is heated by the current. The other part or element may be in the circuit or not; but in either case formed or arranged to be less sensibly heated than the other.

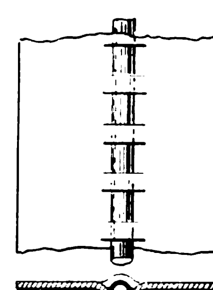


Fig. 3.

It will readily be seen, however, that to heat one or both of the parts of the device in this manner would be clearly equivalent to connecting them both in series in an electric circuit. Unlike the case where magnetic action is employed, the force here available is very considerable, so that to make the instrument self-recording it is only necessary to attach an inking device to the free end and move in front of it a properly ruled chart. In this respect we have no difficulty whatever. My associate, Professor Bristol, who has done the larger part of the work, has since our first experiments very much simplified the method of constructing the differential bar, and the one used in the instrument exhibited was made by placing a flat strip of german silver between a pair of dies which make alternate depressions and elevations along the length of the bar; the wire, insulated with asbestos was then slipped in the tube-like space thus formed, and the whole pressed between plates pro-

1. Read before the American Institute of Electrical Engineers, New York, November 13th, 1888.

vided with grooves of the proper depth, so as to leave the wire to one side of the centre line and at the same time to insure its being held firmly by the little bridges along the length of the bar. Since the bars can be constructed essentially by these two machine operations it is evident that they may be readily reproduced and at very small cost.

We have determined experimentally the best relation between the cross-section of the strip and wire to give maximum deflection. We believe the instrument could readily be made integrating but doubt the desirability of doing so. Our reason for this could probably not be better expressed than in the words of an eminent engineer, Mr. Charles E. Emery, in his paper on "Heating Cities by Steam," before the Franklin Institute, which we quote as follows :—

"It was at first considered unfortunate that a reliable meter could not be obtained, which, like a water meter, would show by differences of reading the quantity of steam used for the interval between observations directly without calculation, and without expense of maintaining a time register at each location, and of integrating the charts afterward. This system, however, proved a blessing in disguise. The greatest difficulty in settling with consumers lies in the fact that employés waste the steam. This is particularly the case during the heating season, when steam for various uses is left on continuously during nights and Sundays, thus increasing the time of consumption from, say, 60 hours a week to 168 hours. In many cases, too, the rate of consumption keeps uniform during the night as well as during the day, so that it is an easy matter to more than double the bills. The consumers at first naturally lay the blame to the steam of the steam company, but the meter charts have been the means of enabling the company to satisfy consumers when, and to what extent, the increased bills were due to mismanagement on their premises."

Substitute electricity for steam, the reasoning will apply perfectly to our case.

Figure 1 is a general view of the differential bar, mounted in a case with inker and recording dial.

Figure 2 is a side view of the important parts, the case being removed.

A. Supporting framework.
B. Differential bar.
C. Inking pointer attached to bar.
D. Clockwork moving dial.
E. Revolving dial for receiving record.

Figure 3 shows a small portion of the bar and a cross-section on an enlarged scale.

THE ABDANK MAGNETIC CALL AND THE ABDANK INTEGRAPH.[1]

BY B. ABDANK-ABAKANOWICZ.

PERMIT me to speak first of a small improvement in magnetic calls. The instrument that you see here, figures 1 and 2, was constructed as long ago as 1882, when calls for telephones were wanted everywhere. The principle of this call is extremely simple. For producing electromotive force we are obliged to move a coil through a magnetic field. I fix my coil at the end of a straight spring, the other end of which is solidly held by the support. On the same support are fixed two magnets that create the magnetic field. If I move the bobbin from its neutral position, thus bending the spring, I am storing up the muscular energy of my hand in the spring. If I remove my hand this energy is restored in a series of oscillations of the bobbin through the lines of force. In this way an oscillatory current is produced in the closed conductor, and the mechanical energy reappears on the other side in the form of the movements of the bell striker. I have made similar calls of different sizes, beginning with half the size of this one (about four inches), up to others where the diameter of the bell was three or four feet. As the electromotive force

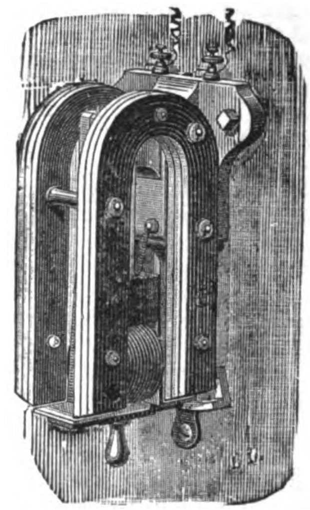


FIG. 1.

developed is very high the working distance is very great. This small one can ring a bell to a distance of over 100 miles over an ordinary telegraph wire. We have tried successfully larger calls on lines over 600 miles.

The apparatus is an old one, and I give the short description of it only as an introduction to some theoretical remarks on its working. In this country, calls approaching to mine, based on the synchronous movement, were patented by Andrews and Watson. Mr. E. Meylen has lately made measurements in my laboratory for the purpose of finding the curve of electromotive forces produced by the passage of the coil across the magnetic field, and this is the subject of my communication to-night.

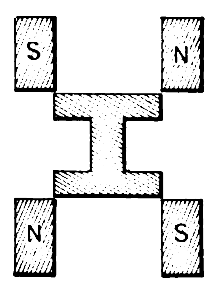


FIG. 2.

If we admit that the instrument is symmetrically constructed and that the magnetic fields are equal in strength, then the curve of induced electromotive forces must have a regular shape. We neglect also the retarding influence of eddy currents induced in the iron core.

We must have the greatest electromotive force in the middle, where the ratio of variation of the quantity of lines of force is the greatest.

The curve obtained by direct measurement was very different in shape, being as shown in figure 3.

This curve presents two remarkable features. First, we see a depression in the middle, where, theoretically, the electromotive force ought to be a maximum. The reason of this is to be found in the defective form of the iron core in the armature. The curves shown in figure 4 will clearly explain this.

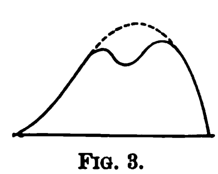


FIG. 3.

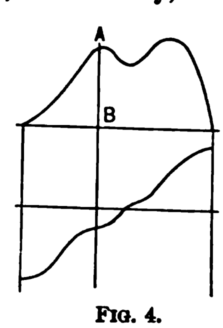


FIG. 4.

This defect in the construction has a very bad influence on the result, the greatest and most useful electromotive force being lost, as shown in the dotted line, figure 3, and the same defect was often found by me in different alternating current dynamos.

1. Read before the American Institute of Electrical Engineers, November 13th, 1888.

The second characteristic feature of the curve is in the shifting of its ordinates in the direction of the movement of the armature. Beginning from the starting point the curve is convex, and near to the other end concave in relation to the middle ordinate.

When the armature moves backward the same deformation was remarked, but in opposite direction.

The electromotive force produced was always somewhat behind the time in which it ought to have been produced. We supposed at first that this was due to the retardation in the indication of the electrometer used for the measurement, but we found by different controlling methods that this was not the case, and that this retardation is probably due to the action of eddy currents induced in the armature core. As you see, the maximum points of the curve are not symmetrically placed. This proves that the magnets did not possess the same strength of magnetic field.

The method used for the measurement of the ordinates of these curves was very simple.

The variation of the magnetic field in the path of the armature was also found experimentally, and then controlled by direct integration of the curve of electromotive force.

The ballistic method was used for the measurement. This method allows of the measurement of the variation of the quantity of lines of force independent of the time. The total variation of the magnetic flux was found to be :

$$\Sigma \, d \, F = 5.1 \times 10^7 \text{ (C. G. S.)}$$

The mean current was 0.021 ampere. The mean power was 0.26 watt.

The curve of the variation of the magnetic field can be found directly from the curve of E. M. F., as before alluded to.

Every ordinate of the curve of E. M. F. is proportional to the ratio of the variation of the number of lines of force.

It is equal to the differential coefficient $\frac{d F}{d x}$

Let us consider the four curves in their relation. Every ordinate, for instance A, B, figure 5, is proportional to the ratio of variation in the corresponding point of the second curve. This ratio is measured by the ratio $\frac{d y}{d x}$ where $d x$ represents time. The ordinate A, B, in a given scale, is equal to the numerical value of the differential coefficient. Every ordinate of the curve of E. M. F. represents the differential coefficient of the corresponding part of the magnetic curve. The magnetic curve is simply the integral of the E. M. F. It is obvious that if the equation of the E. M. F. were given, it would be possible to find the magnetic curve by integrating this equation.

This integration can be performed mechanically by an integrating machine. There is one of these machines constructed in Zurich, by the celebrated constructor, Coradi. To perform the integration it is sufficient to follow with the tracing point the given curve. The integral curve is then mechanically traced by the instrument. (M. Abdank here exhibited his integraph and explained its action.) The integration of differential equations is a problem that we meet continuously in the physical sciences. We perform an integration in determining the area of a given figure ; also in determining the static moments and the moments of inertia, in calculating the shape of the elastic curve.

The planimeter, as you know, gives mechanically the area and the moments. The instrument that you see before you gives much more. It traces a curve that indicates how the integral increases. The curve is the integral curve, the applications of which are extremely numerous. You have seen one of these applications for the determination of the magnetic curve.

I am glad to have had the opportunity to present it to this electrical society, and, as it were, smuggle into your presence a mathematical instrument under the cover of an electrical application. And I do so because the apparatus interests me personally, being myself the inventor of it.

I must also crave your pardon for having addressed you in English, of which language I am not at all a complete master, and I am ashamed, because that lack of knowledge is entirely contrary to my principles. I am of the opinion that every electrician ought to be able to speak English. He cannot be a good electrician without being a complete master of that language. Without an intimate acquaintance with the works of Faraday, he is not able to draw conclusions in a simple and logical manner from experiments. He cannot, without being in direct communication with the legion of workers in electricity who speak the English language and who have advanced electricity in this country to a point where it is 50 years ahead of that in Europe, I say, that without knowing it intimately, he cannot keep track of what can be done with that power of nature which we are all attempting to harness.

THE KEARNEY (NEB.) WATER POWER AND ELECTRIC DISTRIBUTION PLANT.

BY D. C. JACKSON.

To the casual observer who gains his impression of the Platte river from the windows of a car on the Union Pacific railway, it doubtless seems impossible that the broad but shallow stream with little water but much sand in its bed, can furnish a magnificent supply of water under high head to be utilized for power. It is a trite saying that Yankee ingenuity and engineering skill cannot be forstalled, and the Kearney water power is a good demonstration. The car window observer sees the water of the Platte apparently coaxed up hill so that in returning to the river from the top of the bluff with a fall of nearly 100 feet, it may turn the wheels of a rising manufacturing city.

The Platte river has an average fall of seven feet to the mile. Through a part of its course it is skirted by bluffs, which in places recede from the river for several miles and in other places run out and disappear. Breaking through these bluffs are "draws" or cuts caused by the erosion of many centurys' rainfall flowing from the country back of the bluffs to the river. At Kearney the bluffs are about two miles from the river on the north bank, and 17 miles up the river they run out. Here head gates are placed from which a canal, 20 feet wide and four feet deep, winds along the hillside for 17 miles to the top of the bluffs at Kearney. As the canal has been open only about nine months, but a small portion of the water is now utilized, the rest flowing over a weir into the tail race and thence to the river two miles south. In the 17 miles from head gates to Kearney, the river falls 119 feet and the canal 24 feet, giving a fall of 95 feet between the waste weir and the river. Of this, 15 feet is lost in the tail race and 80 feet may be utilized upon the wheels. At present the average depth of water on the water weir, which is 100 feet long, is nine inches, giving approximately 2,000 available horse-power. With the canal deepened and widened five times this power can be rendered available. The canal passes through a region in which no rock is encountered, hence enlarging it is a comparatively simple matter.

The shifting sands of the Platte river cause difficulty at the head gates by drifting in and filling the water passage to the canal. The highly interesting plan of a "rising basin" by the bank, but disconnected entirely from the river has therefore been the resort. Underlying central Nebraska is a gravel bed, through which flows a sheet of water which practically constitutes a portion of the Platte river and carries more water than the surface channel. The underground sheet has been tapped by a flume extending up stream along the river bank to a distance sufficient to gain a head from the underlying gravel. Though the works are

not yet completed, the success of the "basin" is practically demonstrated. When the basin is fully completed the canal will be supplied with water from a practically inexhaustible source, with which no expense will be entailed for annual repair of wash-outs, dams, and removal of sand bars.

In its course the canal crosses a number of "draws" which have been dammed, forming lakes (figure 1). These vary in area from 45 acres to 115 acres and in depth from 10 to 40 feet, thus serving as reservoirs of supply from which water may be drawn in cases of emergency.

It has been planned to place bulkheads at the Kearney end of the canal to serve as forebays, from which to conduct water to the wheels. One bulkhead is designed for the supply of three wheels, and one wheel has been set. The wheel is a 15 inch twin horizontal turbine set 40 feet below canal level, and fitted with draft tubes 20 feet long. Only 60 feet of the 80 feet head available is now utilized. Water is conveyed from the bulkhead to the wheel through a boiler iron tube 60 inches in diameter. The turbine develops 375 horse-power as now set, and runs at 550 revolutions per minute. The "twin" type of wheel gives an equalized pressure which makes the wheels capable of the severest duty, and the high head makes a power which is unequaled for steadiness under constant load. The high speed gives an advantage in belting direct to the dynamos of the transmission plant not equaled by the best high speed steam engine. In central Nebraska the cheapest soft coal, slack, coming from Wyoming, costs $3.75 per ton. In the eastern part of the state, Iowa slack coal of the cheapest grade costs about $2.00 per ton. The value of this prairie water power is evident. The population of the plains consume large quantities of manufactured articles made in eastern mills from raw products grown by themselves. Manufacturing has developed in the coal states east of the Missouri river, but is rendered impracticable through the cost of fuel, where steam is the source of power, in Nebraska, Kansas and Dakota. Kearney's location is such that there is every reason to believe the water power will make it a milling centre.

The topography about Kearney makes it inconvenient for manufactories to take power direct from the canal, and a distributing agent is required. The advantages of electric distribution of power over other methods have led to its adoption. The conditions require a plant covering a semi-circular area with a radius of about 8,000 feet, the power house being at the centre. The conditions of supply being that motors from the largest required down to those of one-eighth horse-power, and incandescent lamps be run from the same circuit. The large area calls for a high E. M. F. for satisfactory distribution, while on the other hand the lamps and small motors set a practical limit of about 220 volts E. M. F. To transmit large power at 220 volts several thousand feet is not to be considered on account of the cost of copper. The arrangement shown in figure 2 has been adopted as satisfactorily covering all conditions. Dynamos capable of producing 275 volts each, are driven two in series, giving a total possible pressure between the positive and negative wires of 550 volts at the dynamo; twenty per cent being lost on the line at full load gives at the lamps and motors 440 volts between the positive and negative wires, and 220 volts between the neutral wire and either positive or negative wire. Incandescent lamps of 110 volts are run two in series. Although certainly not advisable under ordinary circumstances, this is giving perfect satisfaction under the conditions at

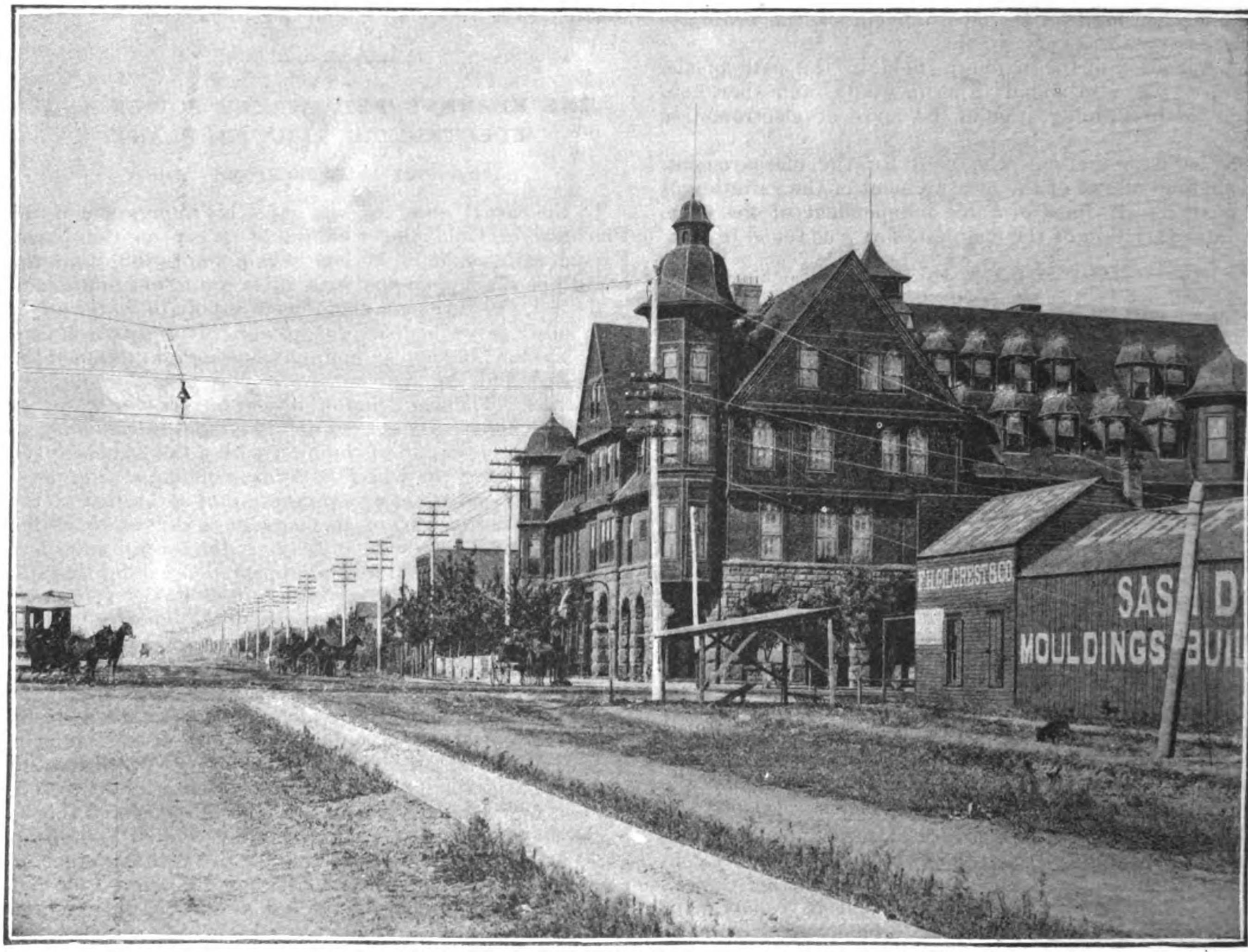


FIG. 3.—Pole Line. Electric Distribution Plant, Kearney, Neb.

Kearney. Motors of less than 5 h. p. are run under 220 volts, being placed between the neutral and positive or

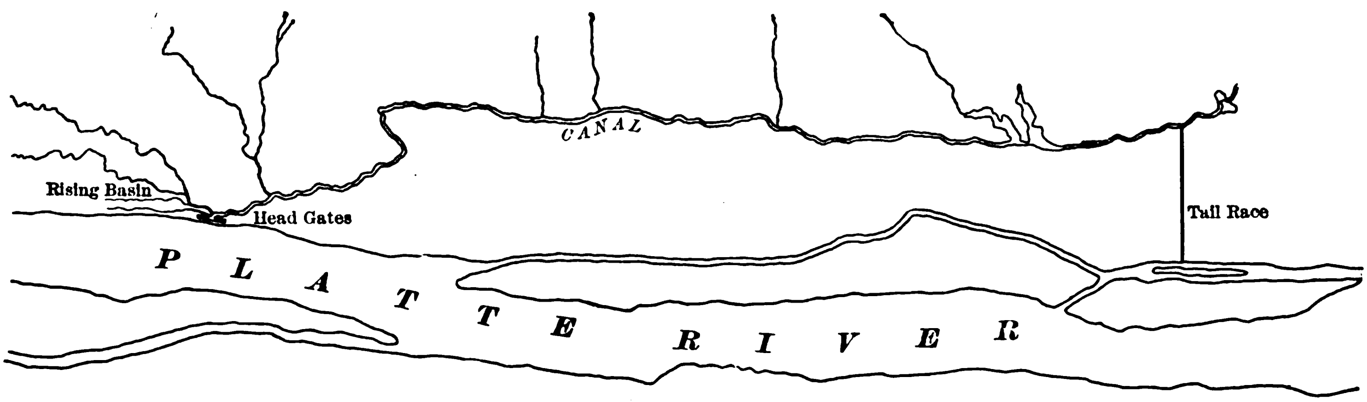


Fig. 1.

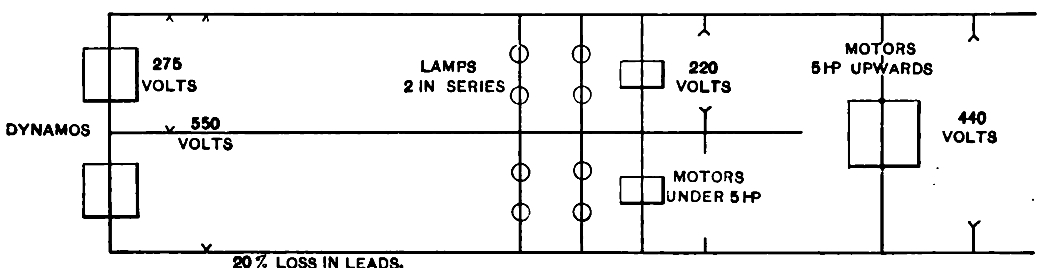


Fig. 2.

negative wire. Motors of 5 h. p. and upwards are connected from positive to negative wires and run under 440 volts. This grading of pressure makes it possible to run a small motor, driving a dental lathe for instance, as safely as a motor of many horse-power. As the plant is designed primarily for the distribution of power, with lighting of secondary importance, the usual methods of regulation of the three-wire system has been slightly departed from. The ordinary pressure indicators connected with load centres, and hand regulation are used, but feeder equalizers are not included. The sudden large variation of current due to large motors makes the effective use of equalizers practically impossible. The feeding points and network mains are therefore designed to keep a difference of potential within about two per cent. variation throughout the system under all loads. This is quite fully accomplished without an abnormal expenditure of copper, notwithstanding the apparent difficulty.

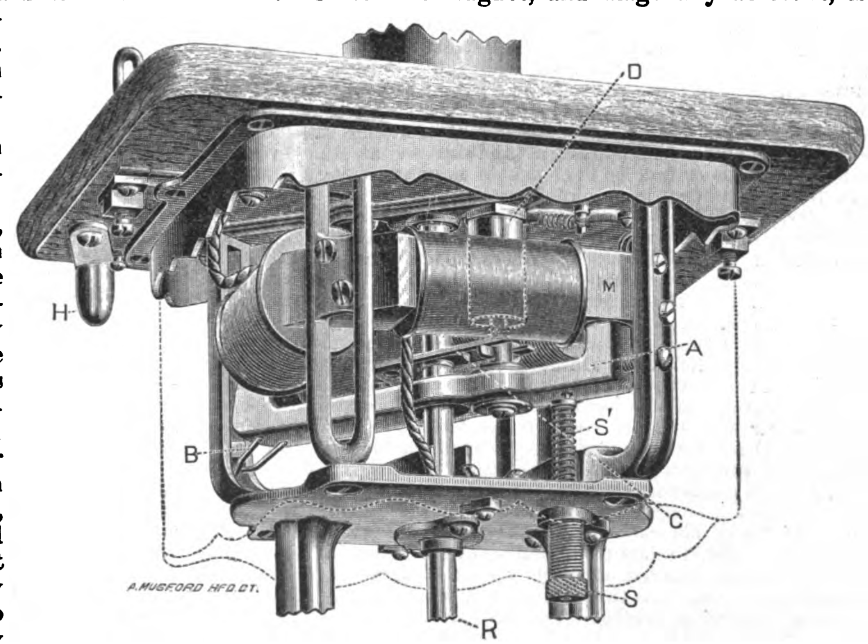
The plant throughout is constructed in the most substantial manner. Ample provision has been made against the two fiercest enemies of overhead wires in Nebraska, sleet and lightning. The dynamos used run at 1,100 revolutions per minute, and are equipped with journals automatically lubricated by the ring method. They easily stand the strain of 23 hours' work out of the 24, to which they are put. The large motors are also equipped with self-lubricating journals and small motors with metallic bearings. The line wire is all of a high test weather proof quality, and inside wiring is run upon porcelain knobs, making the insulation good, and rendering danger from leakage and grounds a minimum. As a whole, the plant is thoroughly provided for the severe duty of 24 hours' run per day from month to month, and power users are practically guaranteed uninterrupted service.

Figure 3 shows a portion of the pole line. A 2 h. p. motor is in service running printing presses. A 30 h. p. motor is employed in driving machinery in the brick works of Hunter and Frank, where a total of 50 h. p. capacity is placed. The motors above mentioned are located on the plant fully 8,000 feet apart "as the crow flies," one being 4,000 feet from the power house in one direction, and the other 7,000 feet in another direction. It is an interesting fact that this 30 h. p. motor is the first electric motor driven on regular power service from dynamos in Nebraska, and is the first motor used for driving brick machinery in the country.

LINCOLN, Neb., Nov. 12, 1888.

THE WATERHOUSE ARC LAMP.

THE Waterhouse arc lamp, illustrated below, has a magnet quadrangular in shape. Two independent conductors are wound upon it, the main being at right angles to the shunt. This produces two poles of constant polarity and two of variable polarity upon the magnet, and the variable poles are utilized in a manner subsequently described. Under the magnet, and diagonally across it, is



pivoted an armature, A, on one end of which is a tongue that protrudes into the elongated hole in magnet M. On the opposite end of armature A, and above supports B, the

armature is rounded and pivoted to the magnet M. While no current is passing through the lamps the pivot holds the armature in place while it rests upon supports B. The tongue end of the armature A is supported by S′. Attached to the armature is clutch C, which binds upon the carbon rod R. The spring S′ assists the armature to form the proper arc, and its tension is regulated by the screw S. Any sudden upward movement of the armature is opposed by the dash pot D, and any sudden downward movement by the spring S′.

The current entering the lamp at the terminal near handle H passes around the main coils, thence to the carbon rod and carbons, returning to the opposite terminal on the lamp board. This produces magnetism in magnet M. The armature A is drawn up, acting upon the clutch which lifts the carbon rod, and the arc is formed. On the burning away of the carbons the excess of resistance is greater in the main than in the shunt coils, and a portion of the current is diverted through the shunt, this neutralizes the magnetism in the variable poles of the magnet, as the shunt pole is an opposite one to the main. The neutralizing of the magnetism allows the armature A to recede slightly by gravitation, easing up on the clutch and releasing the carbon rod, which feeds the lamp. There is no sudden drop of the carbons, however, because the armature A is free from all mechanical friction and directly susceptible to the changes in the magnetism in magnet M. A fine steady feed will therefore be maintained.

An automatic cut-out (not shown in the illustration) is placed on the other side of the magnet, and will cut the lamp out on a quarter of an inch separation of the carbons.

The Waterhouse lamp is thoroughly insulated, is said to be easy of adjustment, and is made with clutch feed, as shown, or with rack and pinion feed.

ELECTROLYSIS OF TIN SALTS.[1]

BY ALEXANDER WATT.

(*Concluded from page 523.*)

4. *Tartrate of binoxide of tin.*—Bichlorate of tin solution was precipitated with a solution of sesqui-carbonate of ammonia, and the precipitate, after being well washed, was digested in a strong and hot solution of tartaric acid, in which the binoxide freely dissolved, forming a clear solution. The concentrated solution was next diluted with about eight volumes of water, and first tried with the current from a single Daniell, which, however, proved to be too weak, so a second cell was connected in series, when on immersing a clean brass plate an opalescent film of tin, of good color, and bright in parts, soon formed; but there was a vigorous evolution of gas at both electrodes. The film, though un-uniform, being in alternate streaks of bright and dull metal, was perfectly reguline, and there was no evidence of loose or spongy particles of metal after half an hour's immersion.

5. *Acetate of tin by electrolysis.*—A quantity of acetic acid, moderately diluted, was put into a glass vessel, and in this was suspended a tin anode and brass cathode, connected to two Daniells in series. In about a quarter of an hour the brass plate received a film of tin, at first white, but gradually assuming a dark-gray color. A single cell was next tried, when the deposit became whiter; there was a considerable evolution of hydrogen, the bubbles of which were of large size, before the plate became coated with tin, but as soon as the plate was covered with the deposited metal, the bubbles became considerably reduced in size, while the gas also escaped more freely from the tinned surface than from the brass. Indeed, the gas bubbles set free upon the naked brass rested for some length of time, until they attained the size of a small pea before rising to the surface of the liquor, whereas from the tinned surface they quickly escaped in small globules.

6. *Acetates of tin and soda.*—Sixty grains of acetate of soda crystals were added to about 10 ounces of the foregoing solution, and the mixture stirred until they were dissolved. A freshly prepared brass plate was then immersed, which slowly received a white and somewhat bright film of tin; this, however, gradually became dull and of a dark color. There was much gas given off at the cathode, which in about 15 minutes formed a thick, white froth on the surface of the liquid. The current from a single Daniell was used, and on examining the anode after a series of trials in this bath, the immersed surface was found to be very bright and clean.

7. *Nitromuriate of tin (dyers' spirit of tin).*—A solution of this salt was prepared as follows:—Sixty grains of sal-ammoniac were dissolved in one ounce of nitric acid, and to this mixture was added, in small quantities at a time, 60 grains of powdered tin. When the tin was all dissolved, the solution was gently evaporated, until a nearly solid mass was obtained, when the vessel was set aside until cold. The product, which formed a transparent, gummy mass, was next dissolved in about 10 ounces of cold water, and after filtration was subjected to electrolysis with the current from two Daniells in series. In this solution a brass plate received a dull but white film of tin—on the surface facing the anode only—after a few seconds' immersion. There was not much gas liberated at the cathode, but it was found that the anode became coated with a yellowish deposit, which, after a few minutes, assumed considerable thickness, while the solution acquired a yellow color, and finally became decomposed, when it ceased to yield a deposit of metallic tin.

8. *Sodio-bichloride of tin.*—Half a fluid ounce of the concentrated solution of bichloride of tin was added to 10 ounces (half-a-pint) of water. Sixty grains of chloride of sodium were then added and dissolved into the liquid, with stirring. The current from one Daniell cell was used, and a brass plate, as before, for the cathode. Immediately after immersion the plate received a good white deposit of tin, and deposition proceeded with perfect uniformity during a long immersion. When the plate was withdrawn the coating was found to be reguline, and there was no appearance whatever of sponginess at any part of the plate, while the anode was perfectly clean. A plate of steel was next put into the bath, and this became at once coated with tin, and at the end of half-an-hour or so received a fairly good deposit of the metal, which adhered well to the steel surface. It is probable that a solution of this composition, if prepared with care, might be found useful as a depositing bath, and since the anode becomes freely dissolved during the electrolysis, the solution would not be liable to vary much in its metallic strength. Another advantage which this solution presents is that only a very small anode surface—about one-fourth that of the cathode—is required. A solution that will coat brass and steel satisfactorily would also be applicable to copper and iron, and since a solution of this character is much needed, it may be worth trying on a larger scale than was necessary for the purposes of the foregoing experiment.

9. *Potassio-bichloride of tin.*—A dilute solution of the bichloride was first prepared, as before, and in 10 ounces of the liquid was dissolved 60 grains of chloride of potassium. The current from a single Daniell was used, and the immersed anode surface was about one-fourth that of the negative electrode, under which conditions, the latter, a clean brass plate, became coated with a pearly-white film of tin immediately after immersion; although the deposit somewhat darkened in color after a time there was no tendency to sponginess—or semi-crystalline character—while the deposited metal was firmly adherent. It may be said that there was little or no perceptible difference between the behavior of this solution and the preceding, but in some respects a preference might be given to the latter—if either could be found practically available.

10. *Ammonio-bichloride of tin.*—Half-a-pint of solution of bichloride of tin was prepared as before (experiment 8) and to this was added 60 grains of sal-ammoniac, in fine powder, and the liquid stirred until the latter was dissolved. The same current and anode surface were employed, when a clean brass plate became coated with a white film of tin immediately after immersion. There was but little evolution of hydrogen, and the deposition, as before, proceeded with perfect uniformity, there being no evidence of spongy metal during a prolonged immersion of the cathode. Although the results obtained from this bath were of a satisfactory character, so far as the metal having no tendency to sponginess, of the three solutions last treated I am still disposed to give the preference to the sodio-bichloride, that is assuming that either of them could be made available for the practical deposition of tin for useful purposes in the arts, which I am disposed to think is not beyond the region of probability.

11. *Tin chloride and pyrophosphate of soda.*—A moderately strong solution of pyrophosphate of soda was first prepared, to which was added gradually a solution of protochloride of tin, allowing the precipitate at first formed to redissolve before making further additions, the chloride solution being cautiously added until the liquid became nearly saturated. The solution was then set aside for an hour or so, and the clear liquor then decanted for use. The solution was then electrolyzed with the current from two Daniell cells, when a clean brass plate promptly received a white film of tin, which, however, soon turned gray, from the formation of spongy metal. The bath was next diluted with water, a little at a time, until the deposit retained its whiteness during a long immersion of the plate. This solution makes a very tolerable tinning bath, but since the anode dissolves but slowly, constant additions of the respective salts in a concentrated form are necessary to keep up the proper metallic strength of the bath.

1. From the *Telegraphic Journal and Electrical Review* (London).

The anode surface should also be much greater than that of the articles to be tinned in this solution.

12. *Sulphate of tin.*—A solution of this salt was prepared by dissolving recently-precipitated hydrate of protoxide of tin in hot dilute sulphuric acid. The solution was afterwards diluted with about 12 volumes of water, and electrolyzed with the current from a single Daniell, when a dull white deposit of tin at once appeared upon a brass cathode. After a short immersion the lower portion of the plate exhibited minute crystals of tin, which almost immediately after spread over its entire surface, and in a few minutes the crystals extended considerably, their growth being almost, if not actually, visible to the eye. The structure of the crystals from the sulphate solution was greatly different from those to which I called attention in the last paper, being of an arborescent or tree-like character; indeed, much like a leafless tree in winter. Some of these crystals were afterwards formed upon a glass plate, as described in the former article, but as they had a tendency to grow vertically as well as horizontally, they were not so well suited to print from by the photographic process as the chloride crystals; it is probable, however, that I may be able to overcome this little difficulty, and I hope to give an illustration of the sulphate crystals in the next paper, which I am anxious to do, as they differ greatly from the chloride crystals in structure. Being desirous of ascertaining whether further dilutions of the sulphate solution would tend to destroy its tendency to yield crystalline deposits, the bath was next weakened by the addition of an equal volume of water, and a fresh brass plate immersed, which promptly became coated with a white film of tin, and continued to retain its reguline character for some minutes, when the deposit gradually assumed the gray and spongy form.

From this and former results it appears that when solutions of tin, which in a more or less concentrated condition yield large crystalline deposits, the same solutions, when considerably diluted, cause the metal to assume a more minute form of crystallization, the agglomerated crystals taking the form of a spongy, but glittering mass. It was interesting to observe that the tin anode, after being used for some time in the several solutions named, acquired the peculiar crystalline appearance known as *moirée metallique*, and that it retained this character throughout a long series of experiments, although it had been considerably reduced in substance by the solvent action of the various electrolytes employed.

13. *Sulphates of tin and ammonia.*—A moderate quantity of sulphate of ammonia was added to the preceding solution and dissolved into the liquid with stirring. The bath was then tried with the current from a single Daniell, when a fine white film of tin was at first obtained upon a brass plate, but after a few minutes' immersion a spongy deposit appeared at the edges and corners of the plate The liquid was now again further diluted with water, and a very small portion of the anode only allowed to dip into the fluid, under which conditions a newly-prepared plate at once received a white coating of tin, and continued to do so without the appearance of spongy metal during the first five minutes, at the end of which time the corners of the plate again became coated with non-adherent and spongy tin. There was no gas evolved at the electrodes. A further dilution was next tried, at which point the solution had become exceedingly attenuated, with a view to obtain, if possible, a metallic deposit, free from sponginess—a reguline deposit, in fact. In the very dilute bath which resulted from the foregoing heavy dilutions, a brass plate now received a very white film, of a pearly hue, and for some time but little change was observable; eventually, however, the inevitable spongy deposit appeared at the bottom of the plate, when the experiment was terminated.

14. *Sulphate of tin by electrolysis.*—A dilute solution of sulphuric acid was first prepared, and in this was immersed a tin anode, connected with two Daniell cells in series, a clean brass plate, as before, being used as the cathode. In this solution, under the conditions given, the brass plate became thickly coated with spongy tin in less than five minutes, while a portion of the same deposit remained suspended from the bottom of the plate in the form of a thick spongy mass, which rapidly increased in bulk. The plate was now withdrawn, and the solution considerably diluted with water, a fresh plate being then immersed, which at once became coated with a white film of reguline metal; this character was not sustained, however, for shortly after the white layer became covered with a loose dark gray deposit of spongy tin. Further dilutions of the liquid were tried, but, as in all the previous trials with the sulphate solution, the deposit invariably assumed the semi-crystalline or spongy state soon after the first white film had been deposited.

15. *Persulphate of tin.*—A solution of this salt was formed by dissolving moist hydrated peroxide of tin in hot dilute sulphuric acid, the concentrated solution being afterwards diluted with about eight times its bulk of water, and filtered. In the solution thus prepared, and with the current from one Daniell cell, a brass plate quickly became coated with white tin, the film, however, gradually becoming rather dark in color after a short immersion. A good deal of gas was liberated at the cathode, and in a few minutes the deposit became of a dark gray color, this *secondary* film, as I may perhaps term it, being, as in all previous cases, non-adherent, while the first, or *primary* film, possessed all the characteristics of good reguline metal, from which the former could be removed by rubbing with the finger.

16. *Sulphates of tin and soda.*—A small quantity of a strong solution of sulphate of soda was added to a solution of tin sulphate, and the resulting liquid electrolyzed with the current from a single Daniell cell, when a white deposit of tin was at once obtained; this, however, soon became dark colored, and in a few minutes the plate was covered with a nearly black deposit of spongy tin. The solution was next weakened by the addition of an equal volume of water, when, on immersing a fresh plate, a pearly white film formed upon its surface, and retained this character for some minutes, when the spongy deposit began gradually to form and appeared in minute but separate lumps all over the plate, leaving the intermediate surfaces speckled, as it were, with the first white film, thus giving the plate a very singular appearance.

17. *Sulphates of tin and magnesia.*—Having frequently observed that an addition of sulphate of magnesia sometimes improved the character of metallic deposits from acid solutions, I added a small quantity of the magnesium salt to a solution of sulphate of tin, when I found that the deposits of the latter metal retained a reguline condition for a somewhat longer period than in some of the former instances, but the advantage was not long sustained, however, for the metal eventually assumed the spongy form; even when the solution was considerably diluted, the same result invariably presented itself, namely, the first layer of the metal after a certain time became coated with the semi-crystalline deposit.

18. *Sulphates of tin and potassa.*—A solution of the mixed salts in varying proportions, yielded results very similar to those above mentioned, and it was found to be practically impossible to keep the deposit in a reguline condition after the first film was obtained, unless the cathode was kept in constant motion, in which case the deposit retained its homogeneous character so long as the agitation was kept up.

19. *Chloride of tin and bitartrate of potassa.*—Sixty grains of cream of tartar were added to a moderately strong solution of protochloride of tin (7½ grains of the salt to each ounce of water) and dissolved into the liquor. The solution was then tried with the current from one Daniell, when a brass plate at once received a fine white deposit of tin, which retained its uniformly white color for several minutes, after which the plate gradually became dark in color, the spongy deposit appearing first at the edges and finally all over the plate. The solution was then diluted with about half its volume of water, and a new plate immersed, which, as before, received a brilliantly white film of tin, and continued to do so for several minutes, when the coating again darkened as before, from the formation of spongy metal, and at the end of about 20 minutes or so the spongy coating appeared all over the plate, but more especially so at the lower surface, where it thickened considerably, and eventually dropped off the plate in lumps. The solution was again diluted, and the experiment repeated, but although the deposition was exceedingly slow, a very small anode surface being immersed in the bath, the pearly white deposit at first obtained, as in the former results, was finally succeeded by the deposition of the metal in the spongy form.

In the last paper it was stated that there was some difficulty in obtaining tin crystals from sulphate of tin solutions, from which photographic prints could be produced direct, owing to the tendency of the crystals to grow vertically upon a flat surface as well as horizontally—a peculiarity which also occurs with some lead solutions, but notably with the nitrate of that metal. Wishing to reproduce crystals deposited from the sulphate of tin solution by the photographic printing process, if possible, I made some further attempts, and after a good many failures, succeeded in obtaining a few fairly good results. To form an electrolyte, half an ounce of sulphuric acid was added to eight ounces of water; this solution was poured into a flat dish, in which was laid a glass plate, 7 × 5 inches, the liquid being allowed to cover the plate to the depth of about one-eighth of an inch. A tin anode, connected to the positive pole of the two Daniells in series, was now laid on the plate, and the negative wire of the battery placed at a short distance from it. With this arrangement, a spongy deposit of tin appeared at the cathode in about 15 minutes; the anode was next shifted to about four inches from the cathode, the spongy metal having been previously removed from the end of the wire, when in a few minutes after the spongy deposit again appeared on the cathode. The anode was then brought within $\frac{1}{16}$th of an inch of the negative wire, and steadily held in that position, when a series of well-defined crystals immediately darted forward from the spongy mass, and were seen to move, with a wave-like motion, in the direction of the anode, when it was gradually drawn away from the cathode to prevent the deposited metal from coming in contact with the positive electrode. In the course of a minute or so, the delicate crystals, which were of a dark gray color, rose to the surface of the liquid, being buoyed up by bubbles of hydrogen which had collected beneath them, and thus the progress of the experiment was checked. The crystals were

now wiped off the end of the wire, which was then replaced, and, as before, brought as near as possible to the anode, without touching, when in a moment crystals again formed, but still more rapidly, and in about half a minute a deposit nearly an inch in length and three-fourths in width appeared, which, as before, rose to the surface of the liquid, and again temporarily suspended the operation. Having thus noticed that definite crystals could be

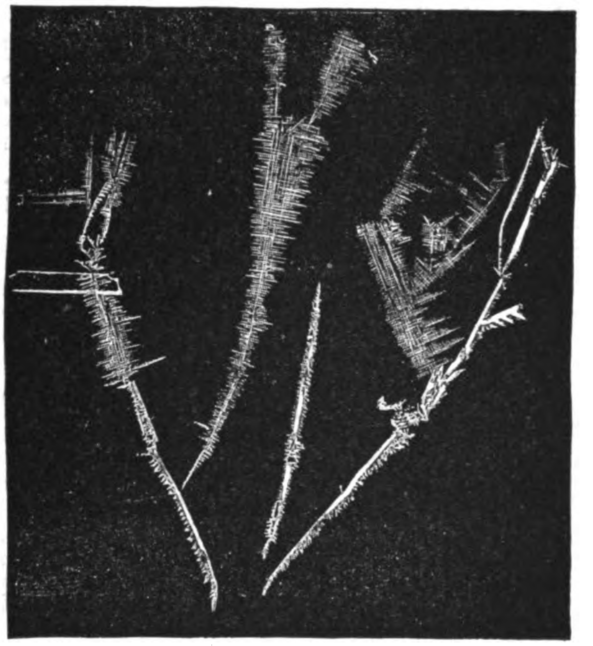


FIG. 7.

induced to spring out from the base of the spongy deposit, I next determined to strengthen the bath by adding a small quantity of a strong solution of sulphate of tin, in the hope of getting a group of crystals *beyond the spongy boundary*, without manipulating the anode in the manner described. To accomplish this, the electrodes were placed about five inches apart, and the bath left undisturbed for about two hours, by which time the following result was obtained: surrounding the negative wire there was a spongy

FIG. 8.

deposit of about one and one-half inch in diameter, from the extreme edge of which crystals, more or less well-defined, had grown, extending in all directions, but of course more especially in the direction of the anode. The result of this experiment is shown in figure 7, the black oval space at the base of the crystals indicating where the spongy mass was formed, and which it was found necessary to remove in order that the photographic paper might lie as close as possible to the crystals in the after process of printing from the plate.

In figures 8 and 9, are shown examples of crystals obtained from the sulphate solution previously described, the first of which (figure 8) was obtained with a wire cathode $\frac{1}{16}$th of an inch in section, and the second (figure 9) with stouter wire. In the three illustrations just referred to it will be seen how greatly the crystals obtained from the sulphate of tin solutions differ from those of the chloride, represented in the first paper of this series.

20. *Chlorides of tin and ammonium.*—A solution of protochloride of tin was first made, containing 7½ grains of the salt to each ounce of water. Sixty grains of powdered sal-ammoniac were then dissolved in 10 ounces of the solution, and the liquor

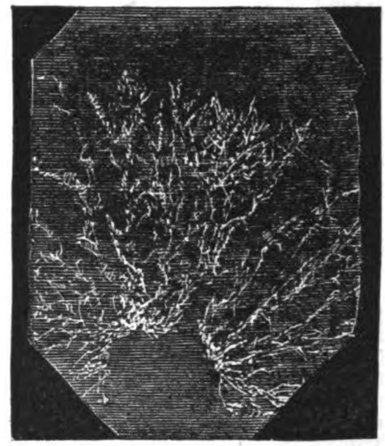


FIG. 9.

slightly acidified with hydrochloric acid. The bath thus formed was worked with a single Daniell cell, when a very prompt and white deposit of tin was obtained upon a brass plate, the anode surface being about one-sixth that of the negative plate. The film retained its whiteness, however, only for a few minutes, when the deposit gradually darkened and assumed the spongy or non-reguline form. The solution was next diluted with nearly an equal bulk of water, when deposition proceeded somewhat more favorably, and the metal retained its reguline character for a longer period than before; after a time, however, the surface of the plate beame coated with a pulverulent deposit, which was readily wiped off with the finger. The plate was then scoured with moist silver sand and returned to the bath, and was kept in constant motion for about 10 minutes, the anode surface having

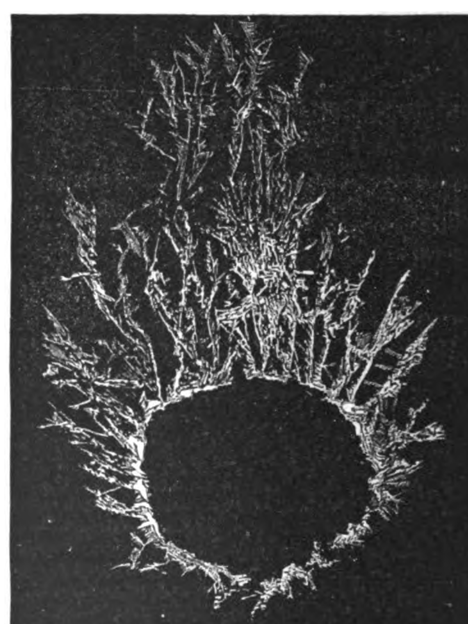


FIG. 10.

been somewhat increased, when it was found that the deposit was quite free from sponginess and perfectly reguline. The plate was again allowed to rest undisturbed in the bath for a few moments, when the coating soon assumed the gray and non-adherent variety of the metal. Another solution of the chlorides of tin and ammonium was next tried, in a somewhat more concentrated condition, when the metal at once deposited in the form of minute crystals, which covered the plate in a few seconds, while a group of crystals quickly started out from the edges of the plate, and in

about 15 minutes after nearly touched the anode, when they gradually drooped and sunk to the bottom of the vessel, where they accumulated with great rapidity, forming a glistening cluster of great brilliancy. This experiment verified what had been before noticed—namely, that the weaker solutions yield smaller crystals of the metal, forming a spongy mass, while they assume larger dimensions and more definite forms in liquids richer in metal. In figure 10 an example is shown of crystals obtained in the stronger bath of the composition given, in which it will be observed that a new crop of crystals appears to grow out of the truncated apex of the upper group of crystals—those which were nearest to the anode. I have found that the growth of these crystals can be considerably modified by altering the position of the electrodes; for example, if the crystals are allowed to approach the anode until they nearly touch this electrode, they invariably assume a flattened appearance, or as if they had been cut off at these points; if now the anode be drawn away from the crystals to the extent of an inch or two, in a few moments after we shall observe that a fresh growth will spring out from the truncated crystals, and, in some cases, these will be of an entirely different character to those of the original group.

21. *Tartrate of Tin.*—A bath was prepared by digesting moist carbonate of tin in a strong and hot solution of tartaric acid, the resulting liquid being afterwards filtered and moderately diluted. With the current from a single Daniell cell a bright and very white deposit of tin was at first obtained, but this gradually turned dull, and after a few minutes' immersion of the plate the deposit was found to be powdery and non-adherent. The metal, however, was readily obtained in the reguline form, and perfectly white, by keeping the cathode in motion while deposition was progressing.

22. *Oxalate of tin.*—A solution of this salt was formed by digesting moist hydrated protoxide of tin in a hot and strong solution of oxalic acid, the liquid being afterwards filtered and moderately diluted. With the current from a single cell a brass cathode received a prompt deposit of tin from this bath, the immersed anode surface being somewhat larger than that of the negative electrode. The deposited metal was of a good white color, though dull, and perfectly reguline.

23. *Peroxalate of tin.*—To prepare a solution of this salt, a quantity of moist hydrated peroxide of tin was digested in a hot solution of oxalic acid, and the clear liquid when cold was sparingly diluted and electrolyzed with a single Daniell, when a brass plate received a coating of tin, but not of a very good color, a few seconds after immersion. The deposit was somewhat irregular and patchy, but otherwise perfectly reguline.

24. *Borate of tin.*—Although this salt usually occurs in the form of an insoluble powder, a small percentage of the hydrated protoxide, or of the carbonate of tin, becomes dissolved in a nearly boiling solution of boracic acid, and the resulting liquid, electrolyzed with one or two Daniells, yields a deposit of metallic tin upon a brass cathode. Beyond this fact, there is nothing of interest in the electrolysis of this solution.

25. *Nitrate of tin*—A solution of this salt was formed by digesting recently precipitated and moist hydrated protoxide of tin in dilute nitric acid, the liquid being afterwards filtered and diluted with water. When electrolyzed with the current from a single cell, a film of tin was received upon a brass plate soon after immersion, but shortly after a yellow deposit formed on the plate, while the anode became somewhat thickly coated with a white insoluble substance—probably a basic salt. The solution being nearly neutral, a few drops of nitric acid were added, and a fresh plate immersed, when a bright and very white film of tin was obtained on a brass plate; this, however, soon became dull, and a yellowish film again formed on the face of the cathode and reguline metal ceased to deposit. It was noticed that in this solution the anode entirely lost the crystalline appearance which it retained in almost all the other solutions tried, while a somewhat firmly adherent and perfectly white salt coated the anode, giving it the appearance of enamel.

26. *Pernitrate of tin.*—Recently precipitated peroxide of tin was digested in dilute nitric acid, and it was observed that the oxide was more freely soluble in a weak than in a strong solution of the acid. A nearly neutral solution of the persalt having been obtained, the current from a single Daniell was passed through it, when it at once became apparent that the liquid became decomposed, a brownish-yellow deposit having formed upon the anode, which rapidly dissolved in the liquid, imparting to it a yellow color. There was no metallic deposit upon the cathode, but a white gelatinous mass formed upon its surface; the bath was now allowed to rest undisturbed for several hours, at the end of which time it was found to have assumed a very peculiar appearance: surrounding the anode, and projecting beyond it to the extent of several inches, a profuse light brown mass had formed, while the whole of the liquid beyond this boundary had been converted into a white gelatinous mass—the contrast between the substances formed at the anode and the cathode respectively being exceedingly marked. On examining the cathode at the conclusion of the experiment, it was found to be very slightly coated with tin of a dark gray color, while beneath the light brown deposit formed at the anode there was found an opaque white stratum, which came away from the plate in hard flakes when scraped with the finger nail. On removing this layer, the underlying surface of the anode presented a brilliantly white appearance, but quite free from the characteristic crystalline appearance which tin invariably assumes when electrolyzed in either acid or alkaline liquids. It thus appears that no less than three different forms of tin are produced during the electrolysis of the pernitrate of that metal, two of which, one of a light brown color and the other white, are formed at the anode, while the remainder of the liquid becomes nearly solid from the formation of a white gelatinous matter, probably a basic salt. It seems difficult to account for the presence of two different deposits at the surface of the anode, but more especially for the light brown color of the deposit overlapping the white layer, which latter was closely attached to the surface of that electrode.

27. *Ferrocyanide of tin in caustic potassa.*—A bath was prepared from this combination as follows:—A solution of ferrocyanide of potassium was added to another of protochloride of tin until the whole of the metal was precipitated as ferrocyanide, which was then filtered and washed in the usual way. The resulting mass was next dissolved in a tolerably strong solution of caustic potash, and the liquid afterwards considerably diluted with water. The bath thus formed was tried with the current from a single Daniell cell, when a prompt and pearly-white film of tin was at once received upon a brass plate, the electrode surfaces being about equal. It should be mentioned that before the bath was put into good working order, increasing proportions of water required to be added, until the solution had become exceedingly weak, in which condition it yielded very satisfactory results, while the anode kept perfectly clean. A clean plate of iron was next placed in the solution, but it was found to become coated so slowly that a second cell was connected, when the iron surface quickly became coated with tin. It is probable that a tinning solution prepared from the above combination might be found useful, and if so it would also have the advantage of being cheaper than some of the baths which have been employed for electro-tinning.

28. *Ferrocyanide of tin in cyanide of potassium.*—A solution was prepared as above, substituting a strong solution of cyanide of potassium for the caustic potash, but the solvent action of the cyanide is so far inferior to that of potash, that its employment cannot in any degree be recommended. Although tin can be deposited from the double cyanide solution of a pearly whiteness, a bath of this composition would be of no service for practical purposes.

29. *Cyanide of tin.*—The hydrated oxides and carbonate of tin are so feebly attacked by even very strong solutions of cyanide of potassium, that we may say that tin solution prepared with the cyanide would be absolutely useless for the deposition of the metal.

30. *Peracetate of tin.*—Having noticed the peculiar behavior of the pernitrate of tin under electrolysis, it was determined to see what results would be obtained with the peracetate, for which purpose a small quantity of solution was prepared by digesting moist hydrated peroxide in a strong solution of acetic acid, moderately heated. The resulting liquid, after filtration, was tried with the current from two Daniells, when a white film of tin slowly formed upon a brass cathode, the deposit eventually assuming a dark gray color. There was a rather brisk evolution of hydrogen, and no non-metallic product formed at either electrode.

In the foregoing experiments, while ascertaining the behavior of various tin salts under electrolytic action, I was also desirous, if possible, to discover some preparation of tin which would be less open to objection than the salts ordinarily applied for depositing the metal, and if I have not succeeded in securing a formula for an absolutely reliable tinning bath, it is possible that some of the results given may be worth further attention at the hands of those who are specially interested in the electro-deposition of tin for commercial purposes.

LIGHTNING.[1]

BY S. A. VARLEY.

(Concluded from page 527.)

Let us now assume the hydraulic view of the transmission of electrical energy to be the more correct one. A suspended conductor may then be regarded as a **U**-pipe full of water. What would happen if water in a rapid state of motion be propelled against one of the mouths of this **U**-pipe. The inertia of the stationary water would effectually prevent sudden transmission through the pipe, and the consequence would be that the potential of the propelled water at the point of impact would be increased in a similar manner to what occurs in a water ram, or

1. From the *Telegraphic Journal and Electrical Review* (London).

what is observed when a hard metal block is struck by an equally hard hammer; the force developed in an infinitely small space would be infinitely great, and the propelled water would either rebound or scatter itself horizontally.

Now I am disposed to believe we have here an explanation of what was observed in the alternative path experiments. When discharge occurs something must give way, and if the B balls be separated beyond a certain distance, the discharge cannot occur in their immediate neighborhood, and as the conductor forming the alternative path, as a consequence of its magnetic inertia, opposes so great a resistance to longitudinal transmission, lateral discharge in a greater or less degree occurs in the air space separating either sides of the alternative path conductor, and also in some degree from it to the walls of the room; and I venture to think if the experiments recorded had been performed in a darkened room, luminous stars would have been observed on the surface of the loop conductor at the moment of discharge, and chiefly at the positive end of the loop.

What I now suggest affords, I think, an intelligible explanation of what was actually observed; the B spark is in all cases produced as a consequence of the magnetic inertia of the alternative path conductor, and if such conductor be an iron one, possessing greater inertia than copper, then the tendency for lateral sparks from such conductor will be greater, and the finer the wire the more readily will lateral discharge occur between the alternative path and the walls of the room. In fact, there would be created a third or C space through which part of the electrical energy dissipates itself, and it must not be overlooked that the walls of the room under such conditions become the two coatings of a Leyden arrangement, and by permitting the accumulation of a statical charge introduce the element of time.

In reference to the behavior of the lightning discharge which struck the vane rod of Doncaster Church, and the phenomena which have come under my own observation, where telegraph circuits having multiple protectors have been struck, I have suggested by way of explanation that something of the nature of momentum is produced by the electrical motion set up in the atoms composing the conductor. I do not wish it to be considered that the explanation attempted is other than a mere suggestion.

What occurred at St. George's, Leicester, and Doncaster Church can be explained by Professor Lodge's alternative path experiments, but that described in reference to multiple protectors cannot, I consider, be so explained. What there takes place is very suggestive of an actual blow being struck, and resembles what occurs when a metal rod receives a sudden mechanical impact.

If a metal rod, A, A[1], figure 7, be mounted on a stand, S, firmly fixed to a bench to prevent longitudinal motion, and a ball, B, suspended by a string rests against the end of the rod at A[1], if a sharp blow from a light hammer be given to the rod in the

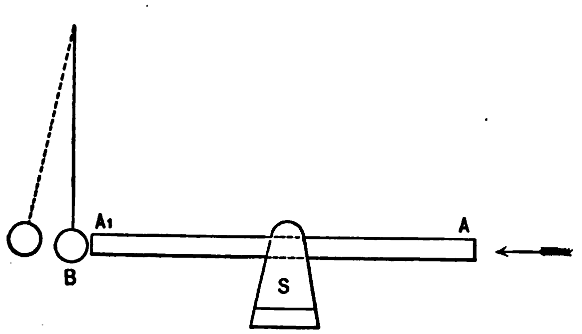


Fig. 7.

direction shown by the arrow at A, the ball will be propelled as indicated by the dotted lines. A similar result may be produced by simply rubbing the rod in the neighborhood of A, so as to throw the molecules into a state of vibration.

Now, whatever may be the cause of the appearance of electrical momentum, the preference manifested by lightning for a straight course when passing through a conductor makes it difficult to my mind to comprehend an electrical discharge leaving a longitudinal path when there is a clear road through it to the earth; but this is what Professor Lodge seems to think does happen, and he attributes it to oscillations and the surging of electric discharges in the lightning conductor, for he says in the first of his two lectures:—"If the earth is bad, the flash can show its displeasure when it gets there by tossing it about, and boring holes into it, and breaking water and gas mains; but at least it might leave the top and middle of the chimney alone, it might wait till it got to the badly conducting place before doing the damage. Yet it is notorious that on high chimneys a flash often refuses to follow a thoroughly good conductor more than a quarter or half way down, but takes every opportunity of jumping out of it and doing damage. Why is this? Well, that is the main question I shall attempt to answer in this course."

I must differ from Professor Lodge when he says:—"If the earth is bad the lightning can show its displeasure when it gets there by tossing it about, etc." Dessicated earth and dessicated wood are good insulators; both owe any conducting properties they may possess to moisture associated with them; this moisture is an electrolytic conductor, and the finely divided water particles become polarized by a sudden discharge, developing, then, enormous resistance. What I have just stated I may, by the way of parenthesis, say incidentally explains the two-fold behavior of the wood table on which the jars rest in the "alternative path experiments." Wood allows of slow conduction to electric currents of any potential, and therefore the charging of the jars was not seriously impeded, but to a sudden discharge the wood becomes practically a perfect insulator, and the discharge consequently leaps a considerable air space in preference to passing through the wood.

We are familiar with two examples of oscillations, viz., the pendulum and the spring; in both cases matter is being acted upon by force, the oscillations being solely due to the fact that matter possesses weight and inertia. Inertia, as stated in an earlier portion of this article, I am disposed to regard as a storage of force. Weight represents the amount of inertia possessed by matter, and rate of motion, it seems to me, expresses the quantity of force stored up in the moving body; for example, four times the force must be expended to give a rifle ball twice the initial velocity of another one; two parts of this force would appear to be imparted directly as velocity, and the other two parts to be stored inside the ball; and, consequently, if the ball be projected vertically it resists the action of gravity for twice the time and travels through four times the space.

I have gone into this subject somewhat at length, because I wish to emphasize the fact that oscillation involves matter. I think it would hardly be too much to say all oscillation we are familiar with are a consequence of a storage of force in matter; if we assume this to be so, would it be too much to suggest that if there be such a thing as electrical oscillation, that matter must be concerned in such oscillation.

Professor Lodge does not seem to doubt the existence of electric oscillations, and he conjectures many millions of oscillations occur in the space of a second in the case of a lightning discharge, consequently it may be considered impossible for their existence to be occularly demonstrated.

Let us, therefore, consider a Leyden arrangement whose rate of discharge is not so rapid. Take, for example, a long submarine cable statically charged to a high potential, it will be found to discharge itself in a precisely similar manner to water through a pipe inserted into the bottom of a reservoir of water where the rate of flow would be determined by the height of the column, and the diameter of the pipe and this rate of flow would decrease as the height of the column of water in the reservoir decreased, there would be no such thing as oscillation under the conditions I have described, but if the discharge pipe were a long one, and if it were elastic it would become distended by the pressure to which it was subjected, and as the pressure became less the spring of the pipe would react forcing back the water, and in this way oscillations might be set up.

Let us now consider what would occur if a charged condenser be connected through a long conductor to second condenser which is not charged, the electricity would rush out of No. 1 condenser through the conductor into No. 2 condenser; the rate of flow in the first instance being determined by the potential to which No. 1 had been charged, and such rate of flow would decrease directly as the potential became lowered by discharge. The magnetic inertia of the conductor would cause a certain amount of obstruction which would have to be overcome; in other words, energy would be stored up in the form of magnetism, and as the potential of No. 1 condenser became lowered, this stored up energy would be given out and the effect would be to continue and prolong the flow into No. 2 condenser, the potential of whose statical charge would thus become raised to a higher degree than that of No. 1 condenser. When this point has been reached a reaction would occur and the electricity would flow now from No. 2 condenser back again into No. 1. The reversal in the direction of the flow involves magnetizing the conductor in the opposite direction, storing up energy again (in a less degree to that previously described) and prolonging the flow into No. 1 condenser. In some such way as just explained it is, I think, conceivable that oscillations may be set up in a conductor, and granted this be so, my contention is that any electrical oscillation which may occur must be set up by some action in the conductor itself; and the only source from which they can proceed, as far as I am able to see, is the magnetic inertia of the conductor. Now if this be the source of such oscillations, then the discharge must take place through the interior of the conductor and not pass over the outside, as Professor Lodge seems to consider to have been "abundantly" demonstrated.

I may remark, by the way, that although the existence of oscillations are taken for granted, there is no suggestion in Professor Lodge's lectures how the oscillations are produced.

Oscillations in a lightning conductor involve the assumption that the earth acts as a condenser and not as a conductor; and

assuming such oscillations do occur, they must be a consequence of the magnetic inertia of the lightning conductor, they can hardly be considered to be produced in the air space separating the clouds from the earth, for if they were developed here the oscillations would be confined to the air space, the lightning conductor and the earth, and they would not surge about through brick walls to conducting matter in the interior of protected buildings, as suggested by Professor Lodge.

I wish to put the matter as fairly as I can. I am no partisan, but simply a student anxious to arrive at the truth whatever it may be. If there be oscillations they must have their origin in some source, and if they rebound from the earth one cannot easily conceive their surging about and reaching the earth through a different channel to that in which they occur. For my own part, regarding the earth as I do as a conductor, I cannot imagine when there exists a good connection between it and the lightning conductor, such a thing as oscillations being set up in the lightning conductor.

During the serial publication of this paper my attention has been directed to some essentially practical lightning conductor experiments published in a contemporary and carried out for them by Mr. Wimshurst. The outcome of these experiments (to quote the words of your contemporary) is to restore confidence in the ordinary lightning conductor.

I am pleased to find the experiments I am now referring to harmonize generally with the conclusions stated in this article as having been arrived at from what I regard as common sense reasoning.

The first set of experiments were made with conductors of copper, and iron wire, copper and iron riband, and iron wire enclosed in a thin copper tube, as below :—

No. 1.	No. 14 B. W. G.		copper wire.
" 2.	"	"	iron wire.
" 3.	"	"	copper riband.
" 4.	"	"	iron riband.
" 5.	"	"	14 iron wire enclosed in copper tube.

The above five conductors were mounted horizontally on glass supports, and placed between two vertical metal plates, one of which represented the cloud and the other the earth. One end of each of the conductors rested against the earth plate, and an air space, the length of which was varied in the course of the experiments, divided the other ends of the conductors from the cloud plate.

The arrangement of the Leyden jars, in respect to the earth and cloud plates, was precisely similar to that of the "impulsive rush" experiment of Professor Lodge, shown at figure 8, the only difference being that the two balls and the pointed conductor shown in the figure were replaced by the five conductors of equal length.

The air space dividing the cloud from the conductors was in the first set of experiments one inch, and this was gradually increased to five inches. At each stage the charged Leyden jars were discharged from the cloud through the air space, the particular rod selected by the electrical spark being noted.

The following results are given as having been obtained when the air space was three inches :—

The copper rod was selected	6	times.
" iron " "	5	"
" copper strip "	5	"
" iron " "	3	"
" copper covered iron was selected	2	"

The distance between the ends of the rods and the cloud was then increased to four inches, and the results obtained were :—

The copper rod was selected	4	times.
" iron " "	2	"
" copper strip "	13	"
" iron " "	3	"
" copper covered rod was selected	2	"

With a five inch air space the results were :—

The copper rod was selected	13	times.
" iron " "	5	"
" copper strip "	0	"
" iron " "	2	"
" copper covered iron was selected	2	"

It is stated that in reference to the above experiments it was considered it would be "unwarranted to draw any conclusions except that the course of the discharge is determined mainly by atmospheric conditions, and that a metallic conductor, if it be of sufficient size to carry the current without destruction, may be of iron or copper, round or flat, as may be most convenient. If we attempt to reckon up the totals of the three experiments, we find that the copper rod shows the best score, and the copper strip the next best; but a comparison of the behavior of the copper strip in the second and third experiments shows that this method of estimation is very risky." To test the action of a bad connection between a lightning conductor and the earth, four other experiments were tried, in which there was an air space between the ends of the conductor and the plate representing the earth, as well as between the conductors and the cloud, and 81 discharges were passed. The following are given as the aggregate results of the four experiments :—

The copper rod was selected	11	times.
" iron " "	20	"
" copper strip "	20	"
" iron " "	13	"
" copper covered iron was selected	17	"

The following remark is made in reference to above experiments : "If we attempt to draw any conclusion, it is that an iron rod and a copper strip stand on an equality, but an examination of the detailed results, which are too long to be given here, shows that the selection was very erratic. One rod would be struck several times in succession, and then would be entirely neglected for a time, and we are forced to the conclusion that the atmospheric conditions had a great deal to do with the path chosen by the spark. When the issue was narrowed by using only two rods at a time, rather more definite results were obtained, and the spark exhibited some preference for the round rod over the strip, but it was apparently the form rather than the metal which influenced the selection."

There is one other experiment made by Mr. Wimshurst, which I would briefly refer to. He constructed a model house, divided into three stories, and in the upper room there were metallic brackets representing gas and water fittings. Down the side of the house ran a lightning conductor, which could be put to earth in various ways ; the gas and water pipes were connected to the earth. Over the house stood a copper plate, representing a cloud. This plate was connected to the outer coating of one Leyden jar, while the other coating of the other jar (figure 8) represented the earth. In the first instance the lightning conductor was metallically connected with the earth, and successive discharges were passed into it from the cloud. There was then no sparking between the metallic roof and the gas and water fittings, either when the roof was connected to the conductor or not.

The importance of establishing a perfect connection between lightning conductors and the earth was shown by the following experiment :—

An artificial earth was constructed by Mr. Wimshurst, in a porcelain dish ; first, a layer of earth one inch in thickness was placed in the dish, then two sheets of metal, having each of them 28 inches of surface, were placed in the mold side by side, but separated by a space between the edges of 2½ inches. Over the whole another layer of damp mold one inch thick was laid, and the entire mass firmly consolidated by pressure. One plate was connected to the lightning conductor and the other to the outside of the Leyden jar, the discharge having to pass through the mold between the edges of the plates, which were 7½ inches long, and through the damp earth in which they were embedded.

Notwithstanding that the humidity of the mold was in excess of that of ordinary earth, in every case when a discharge occurred through the conductor from the cloud, part of the discharge leaped from the roof across a space of 1½ inches of air to the gas bracket, and got to earth that way; and this also occurred whether the lightning conductor was connected to the roof or not.

When the lightning conductor was not metallically connected with the roof then part of the discharge leapt through a space of air from the conductor to the roof, and thence from the roof through a second air space to the earth through the gas bracket.

The above experiment confirms my criticism of that part of Professor Lodge's lectures where he states the only effect of an imperfect connection between the conductor and the earth would be a tossing about of the ground and boring of holes in it; but, as I have pointed out, from the nature of the earth considered as a conductor, the check which an imperfect connection with it opposes to lightning would be very great. Mr. Wimshurst's experiment seems to me also to confirm the views expressed by me when referring to the failure of the elaborate lightning conductor system adopted for the protection of the Hôtel de Ville, of Brussels, which, regarded from the standpoint of "Modern Views of Electricity," Professor Lodge considered to be theoretically, and in all other respects, perfect. In that part of my article I stated I was disposed to believe the surging of currents through lightning conductors, to which Professor Lodge gives so much prominence, is more imaginary than real, but that I could readily imagine numerous conductors over a building may, under certain circumstances, be a source of real danger where there is an imperfect earth connection, for the electricity will then diffuse and dissipate itself wherever it can, and find its way to earth by numerous more or less imperfect channels;" and further on I state that such vagaries as breaking its way through chimney shafts to the heated soot inside, or through a wall to a gun, or fire irons, or a water tank, are, I believe, to be attributed primarily to the want of a good connection with the earth, and not to oscillations or surgings of the current in a conductor.

Professor Lodge describes an experiment made with two ribbons of tinfoil, 21 feet long and 3 inches wide. One of these was zigzagged backwards and forwards, with three sheets of paraffined

paper between the zigzags, and the other was wrapped as a spiral on a glass tube also insulated with three layers of paraffined paper.

It was found when the tinfoil zigzag formed the alternative route of the "experiment of the alternative path," the A space being 7 3, the critical or B spark was shortened from 11.1 to 0.6, and when the spiral was substituted for the zigzag, the B spark was lengthened to 6.4. It was further found that the insertion of a bundle of iron wires inside the glass tube had no perceptible effect whatever on the length of the B spark, which was 6.4 whether the bundle of iron wires was inside the tube or not at the time of discharge. This experiment, to my mind, is a very unsatisfactory one, and in lectures given professedly to assist practical men, in my opinion it would have been better to have omitted it.

Professor Lodge himself admits there are points in the experiment which "require further examination," but at the same time he bases argument upon it as if the experiment were a perfectly satisfactory one; this is a defect which seems to me to characterize the lectures of Professor Lodge as well as the articles on "Modern Views of Electricity." Able as they are, there is a tendency to fit the facts to the theory which is being championed.

The suggestion I should be disposed to throw out in explanation of the results obtained with the tinfoil spiral is that the insulation of the paraffined paper was not sufficient to effectually resist the passage of the high potential charge, and that probably neither in the zigzag nor spiral experiment did the whole of the discharge pass throughout the length of 21 feet. In the case of the spiral, the effect of the insertion of the bundle of iron was to further reduce the amount of discharge which followed the spiral course, the remainder and the greater part passing through the paraffined paper much in the same way as in the Wimshurst experiments, where the earth connector was not perfect.

If I follow the reasoning of Professor Lodge rightly, he seems to think it possible for a current of electricity to circulate round a mass of soft iron so rapidly as not only not to magnetize the iron, but also to meet with *no* resistance to its rate of motion.

He says, in reference to the experiments I am now commenting on: "Here is a magnetic time lag raised to an extreme. Professor Ayrton tells me they have noticed that the permeability of iron begins to diminish with very quick alternations. Here it is becoming virtually no bigger than that of air." Now, I am bold to say you cannot send a current round a mass of iron without doing something, and the work performed resists the rate of motion of a sudden electrical discharge. It is impossible to render inertia non-existent by rate of motion; on the contrary, it is just in those cases where there are rapid alternations of electric currents that the inertia opposed by a conductor or a mass of soft iron becomes the all-important element to be considered. I take it (but at the same time, I speak subject to correction), that if a perfectly hard bullet be propelled against a larger mass of equally hard matter suspended in space, the inertia effects exhibited by the mass will be as the square of the velocity of the impact, and I believe it will be found that magnetic inertia behaves in respect to electrical motion the same as material inertia does to mechanical motion.

If an electrical current be sent through the primary coil of an induction coil from a battery by an ordinary telegraph key or tapper, and a galvanometer be included in the circuit, it will be observed that the galvanometer needle hangs fire, and is not immediately deflected at the moment of contact, owing to the magnetic inertia opposed chiefly in this case by the iron core, and the chemical action or electrical motion in the battery is as a consequence retarded by this inertia. If the two ends of the secondary coil be joined together before depressing the tapper, it will be then observed that the galvanometer needle does not hang fire to so great an extent. When the tapper is depressed and the greater rapidity of deflection observed arises from the fact that an electrical current is developed in the secondary coil in the opposite direction to that circulating in the primary wire *instead of developing magnetism*, and if a series of momentary currents be now sent through the primary coil by means of the tapper, the greater part of the chemical energy developed in the battery will be converted into electricity *instead* of overcoming the magnetic inertia of the soft iron. Still, as the insulated wire of the secondary coil possesses magnetic inertia and opposes resistance, there will be a retardation of chemical action in the battery, but in a less degree as a consequence.

I have referred to this matter in an earlier portion of this article, where I have stated very positively that the whole of the mechanical force consumed in giving motion to an alternating dynamo machine, with the exception of a comparatively small percentage, is converted into electricity *instead of* magnetizing the soft iron cores of the revolving armature. Now it is simply impossible in Professor Lodge's experiment that the electrical discharge circulated round the glass tube, having a bundle of iron wires inside, without doing work of some kind, and such work, whatever it was, would retard the rate of motion, and therefore the conclusion I come to is, that as the insertion of the bundle of iron wires in the glass tube produced no observable effect, the electrical discharge did not circulate round the tube, but found an alternative path through the paraffined paper.

There is a practical experiment anyone can try for himself, showing the bearing of an imperfect connection between a lightning conductor and the earth, which Mr. Wimshurst's experiments has reminded me of. Take a Leyden jar, and one constructed of an ordinary test tube will be quite large enough for the purpose, surround the outer coating of the jar with a single layer of paper, grasp it in the hand, and charge it. After it has been charged, discharge the jar by means of a bent wire, taking care to press one end of the discharging wire firmly in contact with the layer of paper covering the outer coating before bringing the other end in the neighborhood of the conductor communicating with the inner coating. At the moment of discharge a very distinct shock will be experienced passing from the hand holding the discharging wire through the human body, and diffusing itself through the surface of the paper grasped by the hand and surrounding the outer coating. The paper owes what conducting properties it possesses to the small amount of moisture associated with it, and the polarization of this moisture at the moment of discharge opposes very considerable resistance. I think in this simple experiment we have practical evidence that an imperfect connection between a lightning conductor and the earth is sufficient to account in a common-sense manner for such vagaries as Professor Lodge refers to the oscillation and surging of lightning discharges in the conductor.

There is an experiment described in the second lecture of Professor Lodge, called the "Experiment of the Bye Path." It is shown at figure 10, and the following is the description given of it: "Take a yard of stout brass or copper rod an inch thick, arrange it in the path of a Leyden jar discharge, and then arrange as a sort of bye path or tapping circuit some very fine wire, such as Wollaston's platinum wire. It may seem absurd for any portion of the discharge to leave the massive rod and take the hair-like wire for preference, especially if an air-gap exists at A or B, or both. Nevertheless a portion *does* choose the fine wire path."

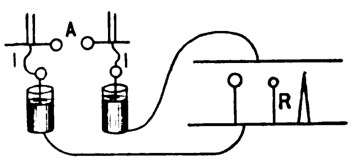


Fig.8.

Now, I think there is a simple explanation of the phenomenon observed without assuming that any portion of the discharge from the Leyden jar leaves the massive conductor. For discharge to occur, the magnetic inertia of the rod has to be overcome, and directly as the sectional area brought under the influence of the electric current, so will be the amount of magnetism developed in concentric rings at right angles to the rod. When a second conductor is arranged parallel to the thick rod, as shown at figure 10, a secondary current is developed in this wire at the commencement of the discharge, and another secondary current in the opposite direction to the first one is developed on the cessation of the discharge through the massive rod, and the magnetism developed in the thick rod *is less directly* as the amount of electricity set in motion in the wire Professor Lodge terms the "bye path."

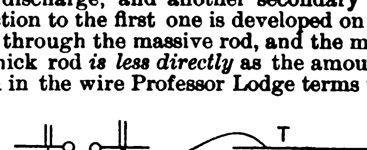


Fig.9.

The action is precisely the same as that observed by me on a much larger scale, when a lightning discharge struck the suspended wires of the Constantinople and Varna circuit, which I have described in an early portion of this article.

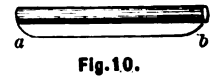


Fig.10.

There are two other experiments (figures 8 and 9) which I will briefly notice. Figure 8 is what Professor Lodge terms the "impulsive rush," and figure 9 the "steady strain."

Both of these experiments seem to me to be very practical ones. The impulsive rush represents what occurs when a discharge from a higher cloud strikes a lower one, which then suddenly discharges to the earth. Professor Lodge's experiments shows that a discharge under such conditions chooses the best conductor, even if it be not the nearest object to be struck, and the fact that the conductor is pointed or not seems to make no difference.

In the experiment of the steady strain where the difference of potential between the clouds and the earth is brought about in a gradual manner, rising from zero until the difference of potential is sufficient to break down the dielectric, then it is found that a pointed conductor though farther from the cloud than other non-pointed conductors, is much more effective in bringing about discharge; indeed, under such conditions, complete discharge may be brought about without any lightning flash occurring.

I take it that in the ordinary course of nature differences of potential between the clouds and the earth are more often reduced quietly than by disruptive discharges, and that when thunderstorms do occur "impulsive rushes" are the exception.

I, myself, believe in a limited protective area, and I think a single point, as long as it remains a point, is as effective, if not more effective, than a number of points.

In an earlier portion of this article I have incidentally given my reasons for such belief, where I have suggested an explanation of how it is a point will discharge a Leyden jar through a considerable space of air.

A great many years since, in conjunction with my late brother, I tried the effect of removing the collecting comb from a frictional machine, and substituting a single point in its place.

The experiment was tried in a room heated to a high temperature, and the dryness of the atmosphere was indicated by a hygrometer. The machine seemed to work as perfectly with the single point as the comb, the same number of turns charging a battery consisting of six half-gallon jars in both cases.

There are a few other experiments described in the lectures I am commenting upon which I should like to have made a few remarks upon, but I feel the time has come when I must bring this article to a conclusion.

The main points on which I am at issue with Professor Lodge are:—

1. I believe an electric current commences to flow through the centre of a conductor, and not first down the outside, as Professor Lodge considers to have been abundantly demonstrated:—

2. I do not believe lightning discharges oscillate and surge about in conductors; and, further, I consider abundant evidence has been adduced to show that an imperfect connection between a lightning conductor and the earth is quite sufficient to explain those apparent vagaries where the lightning has left the main conductor and reached the earth by other channels.

I quite agree with Professor Lodge that it is not a question of "flights of fancy," but one of downright fact. The question whether the flow commences in the interior or the outside of a conductor can be readily determined, I believe, by direct experiment, and I hope to be permitted shortly to do this. I have called attention to the fact that we have Leyden arrangements involving time in their discharge, as well as Leyden arrangements whose rate of discharge is so great as not at present to be measureable. We can follow the discharge and observe what occurs when this is taking place in the slower Leyden arrangements, and what we there observe I contend helps us to understand what occurs when an electrical discharge takes place much more quickly.

If a lightning discharge be a rapid oscillation of electricity on the outside of the conductor, there must be something to produce such oscillations which are not observed in the discharge of slower Leyden arrangements. I think, therefore, it would not be too much to ask Professor Lodge, on public grounds, to explain how he accounts for the surging about and oscillations of lightning discharges, on which so much stress has been laid in his two lectures on the protection of buildings from lightning.

POINTERS.

.... ELECTRICITY can now be produced by steam at 8d per kilo watt per hour.—*W. H. Preece.*

.... THE holiday tourist when admiring the splashing water dashing over the stones hardly realizes that the money loss is as if the foam were composed of flakes of silver.—*Professor Ayrton.*

... IT seems incredible that having utilized this great power of nature to such a wide and general extent, we should be still in a state of mental fog as to the answer to be given to the simple question—What is electricity?—*W. H. Preece.*

... THERE is no branch of physics pursued with more zeal and with more happy results than that of electricity with its allies, and there is no branch of science towards which the public looks with greater hope of practical benefits.—*Sir Frederick Bramwell.*

.... WE are learning daily what sort of properties the ether must have. It must be the means of propagation of light; it must be the means by which electric and magnetic forces exist; it should explain chemical actions, and, if possible, gravity.—*G. F. Fitzgerald.*

.... I THINK, therefore, that it is not in the inventors that we have to look for goaheadedness, but to men of capital who are technically instructed. I think it is technical instruction among the moneyed classes that has developed electrical engineering so much in America of late years.—*Professor George Forbes.*

ABSTRACTS AND EXTRACTS.

DISCUSSION ON LIGHTNING CONDUCTORS AT THE BRITISH ASSOCIATION.[1]

ON the 11th September, Sections A and G joined for the purpose of debating on the question of the "Construction and Efficiency of Lightning Conductors," the leaders of the discussion being Mr. W. H. Preece, F. R. S., and Professor Oliver Lodge, D. Sc., F. R. S. Professor Fitzgerald was in the chair, and called upon Mr. Preece to open the debate.

Mr. Preece, in commencing, commented upon the very small amount that had been learned about atmospheric electricity during the last century. Until quite recently Benjamin Franklin's work, published 140 years ago, contained almost all that we knew on the subject. As late as 1881, there had not been published even a code of instructions with relation to the methods to be adopted to protect buildings from the destructive effects of lightning discharges. Hence in 1878, it was agreed to establish a conference to consider the matter in its practical aspects, and to draw up such a code of rules as was needed, and for this purpose the assistance of the members of the Institute of British Architects, the manufacturers, and press of this country was requested. At the 1881 meeting of the British Association a report was presented by this conference. The results arrived at were to be found *in extenso* in a book on the subject published by Spon. The following passage, extracted from this report, would form the basis of a good deal of the debate: "A lightning conductor fulfills two functions—it facilitates the discharge of the electricity to the earth, so as to carry it off harmlessly, and it tends to prevent disruptive discharge by silently neutralizing the conditions which determine such discharge in the neighborhood of the conductor. To effect the first object a lightning conductor should offer a line of discharge more nearly perfect and more accessible than any other offered by the materials or contents of the edifice we wish to protect. To effect the second object the conductor should be surmounted by a point or points. Fine points and flames have the property of slowly and silently dissipating the electrical charges; they, in fact, act as safety valves. If all these conditions be fulfilled, if the points be high enough to be the most salient features of the building, be of ample dimensions, and in thoroughly perfect electrical connection with the earth, the edifice with all that it contains will be safe, no matter from what direction the storm cloud may come, and the conductor might even be surrounded by gunpowder in the heaviest storm without risk or danger. All accidents may be said to be due to a neglect of these simple elementary principles. The most frequent sources of failure are conductors deficient either in number, height, or conductivity, bad joints, or bad earth connections." The paragraph concluded with the emphatic assertion—which assertion the speaker was there to defend—that "there is no authentic case on record where a properly constructed conductor failed to do its duty." The conference had not failed to take notice of the teaching of modern theory. It had, as its report explained, assumed "the conductivity of equal lengths and weights of iron in the case of steady currents of electricity," and, moreover, that "the suddenness of lightning discharge modifies the conductivity." The report was signed by Grylls Adams, W. E. Ayrton, Latimer Clarke, E. E. Dymond, G. Carey Foster, D. E. Hughes, Hayter Lewis, W. H. Preece, G. J. Symons, and J. Whichcordy, all of whom had had great personal experience of lightning conductors. Lectures had been instituted by the Society of Arts in memory of the late Dr. Mann, who had done a good deal of experimental work with regard to lightning conductors in South Africa; and since this was the case, the subject of protection of buildings from injury by lightning had been chosen as the subject, and Professor Oliver Lodge had been chosen as the lecturer. Expected to eulogize the work of the British Association Conference, he had, like Balaam of old, disappointed those expectations by condemning the conclusions to which that conference had come. If all that Dr. Lodge had asserted was true, the whole work of 140 years had been wasted—no lightning conductors could possibly protect, nor was it possible to safely lead away a lightning discharge to earth.

Mr. Preece said that his duty now was to show that there had been a good deal that was fallacious both in Dr. Lodge's lectures to the Society of Arts, and in a paper of his upon the same subject which had appeared in the *Philosophical Magazine* (August, 1888). In the first place, according to Dr. Lodge, a lightning conductor formed part of the path of the flash. This was never really the case. The lightning rod was erected to prevent the flash occurring; and the fact of its being struck was sufficient to prove it a faulty protector. But even allowing that the lightning does actually discharge through the rod, the latter would form a very small fraction of its whole path. Much depended on the height of thunder clouds. Dr. Mann, in South Africa, had estimated their height as about 650 feet; M. Lacoine, in Turkey, had made measurements which gave a height of 325 feet. These results were probably accurate ones. Mr. Preece had himself come to the

1. From *Industries*, November 9, 1888.

conclusion, from recent observations in Wales, that our lightning flashes had an average length not greater than 500 feet. Experiments carried out by Sir William Thomson and Dr. Warren de la Rue, with regard to the striking distance across an air space for steady currents, showed it to be, speaking from memory, about 30,000 volts per centimeter. If a flash, then, were 500 feet long, and it varied directly as the striking distance, then the measurements given in Dr. Lodge's papers would be about right; but in all probability the striking distance did not vary directly as the length, particularly in the case of alternating currents. According to Mr. Acheson's investigations on the currents produced by transformers, the striking distance varied as the cube of the electromotive force into the capacity. Hence, if this were correct, the electromotive force necessary to force an electric current through the air was considerably less than was formerly supposed.

Moreover, a flash of lightning always goes along a path that has been prepared for it. It does not come down with a rush upon objects which it strikes. Wherever lightning flows, all evidence shows that preparation has been made for its passage. Again, an assumption of the instantaneity of the flash had been made—an assumption which he (Mr. Preece) was not prepared to grant. There was no proof of it. How long the flash really lasted it was impossible to say. There were dark flashes, which never are visible at all—cases were on record where these have been fatal. The effects of lightning discharges upon telegraph lines were good arguments against its instantaneity. When the lightning does enter a wire, currents are produced of sensible duration. The compass needles on board ship could not be affected, as they are, by lightning, if the flashes were not far from instantaneous. On this point photography should be helpful. Then came the question of the alleged oscillatory character of the lightning flash—an idea due rather to mathematical reasoning than to absolute observation. He was sorry to say that there were some mathematicians who allowed themselves to become the slaves of their science. He might say that engineers had no very great respect for mere mathematical development unless it were supported by experiment. And this theory of the oscillatory nature of a flash of lightning was one of the mathematical deductions that must be received with caution. Several facts were opposed to the theory; electro-magnets certainly were excited for a sensible length of time by a lightning flash; needles were magnetized and demagnetized; electrolytic actions were effected. He had frequently heard letters telegraphed by lightning. On one occasion he distinctly heard the letter "R" signaled by this means—this letter involving three distinct currents to produce it. Even "G," requiring eight alternations, had on one occasion been produced. Either, therefore, the flash could not oscillate at all, or else the oscillations must be exceedingly slow to produce these effects. It was very doubtful whether this oscillatory movement took place in lightning flashes at all. It might occur in condensers; but they were not dealing with condenser discharges. Flashes of lightning were more nearly analogous to the breaking down of the dielectric than to the external discharge of the condenser where oscillations do occur. Of the existence of *slow* oscillation in the flash there was abundant evidence. Professor Elihu Thomson had proved it to exist in some cases by wagging his head while observing a flash.

To go on to a point which Dr. Lodge had raised, and which was of immense importance. As a parenthesis, there was no man who had worked so thoroughly and honestly in this direction as Dr. Lodge, and no one with whom it was a greater pleasure to carry out a discussion, because of the harmony and good feeling that he showed. Dr. Lodge had performed the following experiment: He had taken a Holtz machine, H, which charged one side

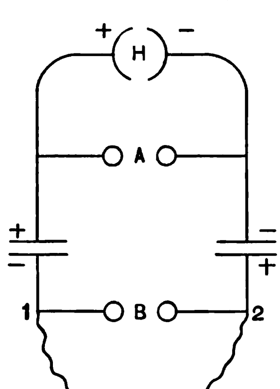


FIG. 1.

of the condenser with positive, and the opposite side with negative, electricity. Then if the points 1 and 2 of a discharger (as shown at the time on a blackboard) be connected by an "alternative path," L, of iron or copper wire, the distance between the knobs B, across which the spark will pass, is much greater than if L is absent. The real discharge is determined by the knobs A. When the condensers discharge, there is simultaneously a discharge at A and B. Dr. Lodge explained this by supposing that, on account of the oscillatory nature of the discharge, there was self-induction in L, a kind of obstruction which caused the charge to pass across at B, rather than travel through the conductor. The spark was longer with copper than with iron as an alternative path. He (Mr. Preece) would, however, give as his explanation of the phenomenon, that the increased spark in the case of copper is owing to increased charge in the condenser; iron throttles the charging current. Dr. Lodge argued from the discharge alone. But it was possible to argue from the charge also. A Holtz machine would set up little pulsations of electricity. Dr. Lodge said that because the spark is longer with copper, copper has more self-induction than has iron. He (Mr. Preece) would say that, as the charge is a pulsating one, the extra spark length is due to the self-induction in iron being greater than in copper.

There were many objections to this self-induction theory, yet it looked as if Dr. Lodge were on the brink of a discovery in static electricity. But that gentleman had apparently overlooked a paper by Professor Poynting, which, had he studied, he would have found proofs that energy passes through the dielectric and not through the conductor, and he might have applied this principle to his experiments. He (the speaker) himself was not sure that Dr. Lodge would not find that there was something in the contact between the conductor and the dielectric. When a charge was passed through a chain of persons, those who suffered most were the end ones. There was some effect between the surface of terminals and the air, of which we are at present ignorant. He wished also to note the fallacy of Dr. Lodge's statement that a lightning conductor protects no area whatsoever. What, then, was the use of it? There was sufficient evidence in the report of the conference to show that this was not the case. Moreover, Dr. Lodge had asserted that extended points were useless; the conference had pronounced them essential. The conference was supported by the experience of the past; Dr. Lodge by mathematical assumptions. Finally, he would say that he had done his best to uphold the conclusions come to by the lightning rod conference. He had feebly endeavored to prove Dr. Lodge's views in some respects fallacious; and he felt that, whichever side were the more successful in the discussion, at least it would have the advantage of bringing to their minds the true theory of electricity, shadowed forth by Professor Fitzgerald in his inaugural address, an address which he believed would mark this meeting at Bath as an epoch in the history of electricity.

Professor Oliver Lodge, D. Sc., F. R. S., in commencing his defense, confessed that he could not boast of a practical knowledge of lightning conductors anything like that which Mr. Preece had obtained from the half million conductors under his supervision, not having himself a single rod under his control. The house in which he lived had not one, nor had the college at Liverpool with which he was at present associated. He had several times asked for one to be put up there, but had been told that it was cheaper to insure. There must be some fallacy in the argument that, because an insurance company is willing to pay if a thing is damaged, it is therefore nobody's business to protect it from damage. However, manufacturers often acted on this principle. It was perfectly true that, if his views were correct, very few buildings were effectively protected at the present time; but then it was also true that, if they were correct, lightning conductors would in the future cost not many more shillings than they at present cost pounds—which, if they are equally effective, would be no slight advantage. Mr. Preece had been poking fun at mathematicians. He (the speaker) was quite prepared to argue the question in hand without the use of a single symbol. Mr. Preece began by saying that there was not an authentic case, no record of a properly constructed conductor failing to do its duty; but a large number of such failures were to be found described in the report of the lightning rod committee. There was one noteworthy one. A brass rod one inch thick fixed on a steeple in Italy had been smashed to pieces and the steeple destroyed, and this had been witnessed by a large number of people. In his lectures last spring, he had quoted as the best protected building in the world the Hôtel de Ville at Brussels, upon which M. Melsens had spent so much time and trouble. That building was protected by innumerable conductors, with admirable earths, and bristling all over with points at the top. Last June it was set on fire by lightning. Books had been written about the elaborate method in which it had been protected, but few particulars of its destruction had been published. Next, Mr. Preece had had a hit at him, where he admitted that Mr. Preece had had the advantage. That gentleman had quoted a sort of Midlothian speech of his, in which he had made an erroneous statement; but he was not introducing that as a statement of mathematical calculation, or anything else of the sort; it was a mere parenthesis thrown in very hastily. Of course, one ought not to do those things; but yet when one wrote much one was very apt to make hasty statements. When asked by the Society of Arts to lecture on lightning conductors, he had resolved to say something about self-induction, having observed that the lightning rod conference had not referred to that question under the

name of magnetic inertia or any other. He happened to be writing a paper which appeared, he thought, in *Nature*; and in that paper, having regard to the magnetic permeability of the two metals, copper and iron, he had stated that, in regard to the magnetizability of its substance, iron was 90,000 times worse than copper. He meant to say, therefore, that although iron was cheaper, was more difficult to melt, had a higher specific heat, and in a variety of ways was better than copper, yet in regard to this electro-magnetic inertia it was enormously worse. Before actually giving the Mann lectures, however, he made a few experiments on this point, and to his surprise he found that, so far from being worse, iron was often rather better; and that even a thin wire of iron carried off the discharge better than a thick wire of copper. This experiment naturally and at once effected his conversion. The experiment referred to was that of the alternative conductor; it might be of iron or copper or any other metal, of any thickness they wished to experiment upon. The top part of the arrangement sketched by Mr. Preece was of no particular interest; at least they need not attend to it now—the bottom part was the thing. The B spark measured the electromotive force which drove the current through the alternative path. They should adjust the B part until the flash produced there did not know which way to go—whether to go through the wire or through the air. Half the sparks failed when that is attained. With a spark micrometer at B they measured the distance, and thus obtained the electromotive force which is on the verge of succeeding in driving the contents of the jar through the wire. He tried first a thick copper wire, and after a thin iron wire of the same length. He found that a greater distance of spark, a greater electromotive force was needed to drive the contents of the jar through the thick copper wire than through the thin iron wire. Whatever explanation might be given of an experiment of that kind, a direct intimation from heaven could be no clearer. For some reason or other the copper and iron are at least equally good. He did not press the point that iron is *better* than copper, and had never stated that copper had more *self-induction* than iron—that would be a mad thing to say; but it might happen for some reason or other, that copper obstructed the current more than iron. He preferred, however, to say that the two metals were equal. Mr. Preece said that the function of a lightning conductor was to prevent a flash from striking the conductor—that is to say, that a lightning conductor ought never to be struck, or it failed; but they are struck, because they get melted, and yet in an earlier sentence Mr. Preece said they never failed. He did not know which of those statements was to be taken as correct. If a lightning conductor could prevent a flash from occurring by its point action, well and good; but he had shown in the lectures (he would not trouble them by repeating a statement of the experiments) that there were cases where a point had no protective action whatever, when it can be struck by a thick and heavy flash. There were other cases where the point acted with a brush or fizz, and neutralized the electric charge without a flash. But they could not always depend upon it doing that, and so the lightning rod had two functions—one preventive if it can, and the other to carry off a flash when it cannot help receiving it. But they must remember that a flash—at least the electric charge—has always a certain amount of energy, and that it has to be dissipated somehow. It is not a question of a certain quantity of electricity which has to be conducted to earth and then there is an end of it; there must be a certain amount of energy, and they must dissipate it somehow. They could not expect to *hocus pocus* energy out of existence by saying they would conduct the charge down to earth; the quicker they tried to conduct it down to earth the more surging and violent disturbances they were likely to get. It might be better to let it trickle down slowly by using a moderately bad conductor than to rush it with extreme vehemence down a good conductor, just as it would be safer to let a heavy weight suspended in a dangerous position slide down rather than to let it drop as quickly as possible. Concerning the length of flashes, he wished he had first-hand information, but he had none; it was one of those things which meteorologists must determine. It was very important to know the length of the flash. He had seen it stated in books that the flashes were a mile long and perhaps more. Mr. Preece thought they were only 500 feet long; that was a matter of fact which could be investigated; but that was a matter upon which he had no direct first-hand information. As to whether the spark length is proportional to the distance or not, he would say that the experiments with oscillating currents, to which Mr. Preece magnanimously called his attention yesterday, were conducted with alternating dynamos between points. Now the area of cloud and the area of earth below it are not points; they are flat surfaces, like the coats of a Leyden jar.

Mr. Preece remarked that they were alternating transformers, when Professor Lodge replied that they were alternating currents as used in practical commercial work discharging between points. There the law did not seem to hold; but then it ought not to hold, so that would be all right. But between flat surfaces it ought, and the spark length ought to vary with the difference of potential between the two flat surfaces. At the same time, if there were points on the earth's surface which were big enough, and if these points determined the flash, then the law of proportionality would not hold. However, the laws concerning discharge in dielectrics were well known, and were scarcely matters for argument. The circumstances of an oscillating current did not apply as regards the length of the spark, because until the discharge occurred there was no oscillation; it was a mere static charge. The earth and the cloud above it are exactly like the coats of a Leyden jar, which are preparing to spark into one another, and which do spark into one another when the difference of potential rises to a certain maximum, and the air between is broken down. The duration of flashes was another point on which much valuable work might be done by meteorologists and photographers. He had seen lightning flashes which certainly appeared to last two or three seconds. He could not imagine that it was one flash which was doing that; he thought it was a series of multiple flashes succeeding one another very rapidly. If any kind of flash can be shown to last long, it is an argument that that kind is not oscillatory. The fact that they deflect a compass needle did not prove anything about it; it did not prove anything concerning their duration either, because a ballistic galvanometer is deflected by momentary kick. A momentary blow given to a thing can deflect it, the blow having ceased long before the motion has ceased which it produced.

The difficulty of the magnetizing power of lightning was one of the strongest points Mr. Preece had adduced. A flash magnetized steel bars, deranged the magnetism of a ship's compass, and produced other magnetic effects. An oscillating current should not produce such effects. An oscillating current with decaying amplitude is used by Professor Ewing to demagnetize steel, not to magnetize it. The oscillating current would have a gradually decaying vibration. That would demagnetize things, but it ought not to magnetize. It does magnetize them; therefore how can it be a current of this kind? But then the same difficulty would be felt with the Leyden jar discharge. The Leyden jar discharge is certainly oscillatory, because it has been seen to be so, when the sparks have been analyzed in a revolving mirror. And yet it magnetized steel needles when sent round them. He did not fully understand that point, and he hoped Lord Rayleigh would say something about it. Mr. Preece was quite right in saying that the whole theory depended upon the existence of oscillations. As far as the theory was concerned, he (Professor Lodge) had merely called attention to these oscillations —which were well known in the case of Leyden jar discharges, and of which the mathematics had been worked out—and pointed out that they applied also to lightning, which he did not think had been much noticed. A pendulum is an analogue of them. Raising the pendulum represents the charging of a jar; charge it more and more, and then discharge it—that is, let it go. When you let a thing go, it naturally swings before coming to rest; it need not, it may meet with too much friction. Suppose it were oscillating in treacle, it would then have a dead beat motion down. It may be a slow leak, the discharging of a condenser through a leak, in which case it would come down very slowly. Those are cases in which there is no oscillation, and it entirely depends upon the friction—the viscosity it meets with. If the friction is very great, if it is like a leak, then it would go down slowly, and there would be no oscillation. If the friction is small, and if there is inertia, then it must oscillate. Mr. Preece admits the inertia. Suppose a Leyden jar going to spark, it possesses potential energy, like a raised pendulum or bent spring; the instant it sparks a current rushes round. They had then a circular current, which was well known to deflect compass needles, to produce magnetic effects. That is the electro-kinetic inertia represented by the ordinary inertia of the spring or pendulum when it passes the middle position. You have first a static charge; then, while it is flying past, you have a current, and magnetic effects, and kinetic inertia, which carries it on to its other extreme position of static charge; and so you have these oscillations gradually dying out on account of the friction. If they made it oscillate in water instead of in air, the oscillations would die out more quickly. They would die out for two reasons; partly because of friction, which generates heat; partly because waves are produced. If they made it oscillate in water, the surface would be disturbed, and waves would travel along; part of the energy would go in heat, and part in waves—that is, producing radiation, or light, as they might call it if it were only quick enough to affect the retina.

He did not know what was the energy of a lightning flash, and wished there were some means of determining it. As to whether lightning was likely to be oscillatory or not, that was a question of resistance (or friction) compared with the capacity and inertia of the discharge. The smaller the capacity, the more likely it was to be oscillatory; the bigger the inertia, the more likely it was to be oscillatory. The capacity discharged in a flash is small, for the quantity is not great, while the potential must be enormous. Finally, there was the question of the area of protection. Mr. Preece's theory on this point could be obtained from a paper in the *Philosophical Magazine*, and the area protected according to this theory was so small that they might almost give it him without argument. Suppose A B a conductor and D E the ground line. Taking the corner of a square (two of whose sides

are A B and D E) remote from B, describe the curve A E, and similarly D A on the other side. Then A D B E would be the protected region—which was not much. If they applied that to every point on a house, they would want a conductor on every point; but Mr. Preece meant that you must put up a rod of gigantic height to bring the whole house into the area. Even then they would not be safe. Why did he object to such a bit of protection as that? Mostly because he thought that areas of protection directed one's attention to side issues—to a thing which it is better not to

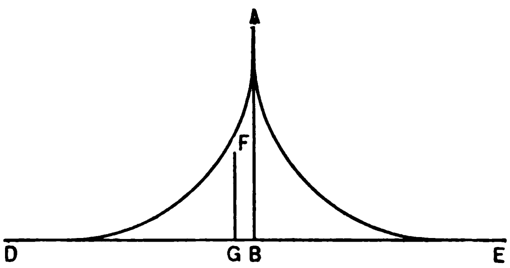


FIG. 2.

think about, because there is no certain area of protection. Take another rod (F G), completely enclosed in this area of protection, and lead it up from the ground to near the lightning conductor, so as to leave a little spark space. If "area of protection" has any meaning, that rod ought to be protected; but he said that when a lightning flash (that was merely an assertion, and they need not believe it) struck that conductor A B, they would almost certainly get a spark down to this supplementary rod F G, which would take its share and assist in conveying the current; therefore, it is not protected. If a man held a lightning conductor when the flash passed down it he would most likely be killed, and if it passed through gunpowder—well, he did not know about gunpowder, because gunpowder got blown about. It did not matter about the earth; let the intended conductor have a good earth and this supplementary one a bad earth, still the same effect will occur; a spark is likely to occur if the distance be not too great. He said that this is so because he had made experiments in the laboratory after this fashion, amongst others. He took a rod which might be of copper as thick as they pleased, he put it in circuit with a Leyden jar, sending the discharge through the rod. This was a solid rod of copper; take a Wollaston platinum wire, or any other wire as fine as possible so as to make the contrast greater, and arrange it to make a kind of tapping circuit; arrange so that the bottom end shall be in contact with the rod, and the top end an eighth or a sixteenth of an inch away. There they had a splendid conductor, better than any lightning conductor ever was. They would have no trouble about earth, as they had a little tapping circuit close to it—the Wollaston wire, which they could hardly see. It seemed absurd for any portion of the discharge to leave this inch-thick conductor to jump across a sixteenth of an inch of air space, and to make for the little thread of wire. Nevertheless a portion of it does, and from every spark that goes through the conductor a side branch goes to that little wire. There was one point where Mr. Preece had not made out the full strength of his case. A thunder cloud is not a good conductor—it is like a spangled jar, consisting of drops of water with spaces between them. There was, therefore, no guarantee that the whole discharges at once. There might be a kind of dribbling away, and thus the oscillatory sudden rush might not take place.

There was another recently discovered point, which could only just be touched on—viz., the effect that the light of one spark had in helping in the formation of others. A spark from one induction coil was able to start a spark in a second coil merely by its light. That was why he said that the idea of the protection of areas was misleading. If one flash caused a lot of others, it was not safe to have that one.

Mr. Glazebrook had just asked him to describe the effect of light in producing a spark. There was no difficulty. Take a common induction coil; separate its terminals till the spark will just not pass. Expose them to the light from a burning magnesium ribbon, and sparks would at once pass, and would stop when the light is removed. The light from the spark of another induction coil or a Holtz machine would have a similar effect. The light of a spark, or ultra-violet light in general, seemed to diminish the transition resistance between the metal pole and the air, especially in the case of the cathode.

The Hon. Ralph Abercromby exhibited a number of photographs of lightning flashes selected from those collected by the Royal Meteorological Society. The first question which might be answered by these photographs, he thought, was—Is there any evidence of the duplication of flashes; that is, of one flash rapidly succeeding another? Of this the photographs seemed to give no evidence. One of them, showing one bright flash with three apparent repetitions of that flash in different places and of varying intensity, seemed to point to an affirmative answer to the question; but they had good reasons to believe that these repetitions were due to reflections of the light from the back of the glass of the photographic negative. Flashes were frequently seen coming close after one another, but there was no photographic evidence that they followed the same path. One photograph from Massachusetts showed the whole field of view filled with fine threads of lightning. He thought that it was important to make investigations in order to find out what influence rain or hail had upon the form of the flash. Photography gave conclusive proofs of the non-instantaneity of flashes of lightning, which seemed to go meandering about the air in an aimless sort of way. There was one evidence bearing on this question which had been adduced as evidence, but which the photographs before the committee did not confirm. In fully half of the photographs the lightning does not cover the plate as a streak, but has more or less of a banded nature, something like a ribbon. It had been suggested that this apparent breadth might have been due to the shaking of the camera, but they had evidence that this was not the case. One of the most remarkable photographs showed three white flashes and a black one. This black flash, according to an early idea of his, was due to the inversion of the photograph, which sometimes, as all photographers knew, took place owing to over-exposure. M. Janssen had made to him a very valuable suggestion, that this might be the evidence not of a peculiarly bright flash which over-exposed the plate, but of a slow moving flash which gave time for the plate to be exposed. Of course it was impossible to say much from one case, but he thought that this was a remarkably brilliant idea. With reference to Mr. Preece's remarks on the height of lightning clouds, it was possible to have them only 500 feet high; but this was very low—in the majority of cases they were certainly very much higher. Electrical disturbance is confined certainly to the lower 10,000 feet of the atmosphere. In connection with the practical bearing of that, he might mention that in Norway they had two kinds of thunder storms. In the summer he believed the thunder clouds were high, and very little damage was done; on the contrary, in the winter time the thunder storm clouds were very low, and the churches frequently get struck. On practical applications he could not offer an opinion; but he was quite certain that great good would result from that discussion.

Lord Rayleigh said that he had no special experience of lightning rods, and could only speak from a general knowledge of electricity. In such cases as the one in point, anything that stood on an *à priori* foundation merely should be received with diffidence; yet it seemed to him that Professor Lodge's experiments appeared likely to have an important bearing on the subject of lightning conductors. He could not see how experiments dealing with the thing of all others most like lightning that they could produce in the laboratory could fail to have such an application. Professor Lodge asked one question, and he thought mentioned his (Lord Rayleigh's) name in connection with it, as to how it could happen that an oscillatory electric current—that was, say an alternate electric current beginning at a finite magnitude and gradually dying away—could produce magnetizing effects such as they well knew it did in some cases; and he instanced the very opposite behavior of slowly dying away alternating currents in the experiments of Professor Ewing and of others, in which such an arrangement was precisely the one adopted in order to get rid of even the last traces of magnetism. The question was a difficult one certainly, and he had intended, in fact, to make some experiments upon it himself; but he was inclined to think that the explanation might, perhaps, be sought in a circumstance very much akin to the one with which they were now dealing, viz., that the steel needle, which was to be magnetized, say, by the discharge of a Leyden jar flowing through a spiral enveloping the needle, was itself a conductor of finite dimensions, in which circumferential currents would be induced. These circumferential currents would, at first, at any rate, protect the interior of the iron from the direct magnetizing action of the enveloping helix. They must think not only of the action of the oscillating current in the helix upon the various parts of the needle, but also of the action of the currents developed in the steel needle itself. It ought to be well known, at any rate it had been well ascertained, that at different depths in such a steel needle they would find very often different degrees and even different directions of magnetization. It seemed to him possible that, if this was thoroughly followed out, they would be better able to understand what was certainly a fact—that a current whose whole value, in some cases measured algebraically, is zero, and is certainly alternating and gradually dying away, does, nevertheless, produce and leave behind it the effect of strong magnetization. It seemed to him that it was only by actual experience of lightning conductors that the question could ever be finally settled. Laboratory experiments must be most important as suggestions, but he thought that no one would wish finally to adopt any system or change any system of lightning protection without actual experience on a large scale.

(*To be continued.*)

.... APPLICATIONS of science and discoveries in pure science, act and react the one upon the other.—*Sir Frederick Bramwell.*

THE DEPTFORD ELECTRIC LIGHTING STATION.[1]

THE total number of gas jets fixed throughout the area which is usually understood when we talk of London, may be roughly estimated at 5,000,000. If all these jets were to be replaced by electric glow lamps, giving the same amount of light, the power required to generate electric current for these lamps would be about a quarter of a million horse-power. The London Electrical Supply Corporation, Limited, propose to supply eventually over a quarter of a million lights, or about one-twentieth of the total supply which would be required for the whole of London. But even this twentieth is a very large amount, as could be realized by the party of press representatives who were invited to view the Deptford works on Wednesday last. The site of the works comprises about 4 acres, with river frontage. The coal will be unloaded from the steamers by hydraulic skips, and run on two railways, one on the ground, and one overhead, into the boiler house. The buildings now in construction consist of one boiler house and two engine houses, the whole occupying a space of 210 feet by 95 feet.

In preparing the plans of the station, Mr. Ferranti, the engineer to the company, has provided for future extensions by leaving room on either side of the building, so that more boilers can be installed by an extension of the building towards the river, and more engines and dynamos by an extension in the opposite direction. The boiler house is 195 feet long by 70 feet broad, and nearly 100 feet high. In it are now being erected 24 Babcock and Wilcox boilers, part of them on the ground floor and part on the first floor. Above this there is another floor, on which about 4000 tons of coal will be stored. The coal will be brought down to the boiler floors by chutes. At each end of the boiler house is a group of chimney stacks, four in each group. Each stack is 6 feet by 18 feet by 130 feet high. Green's economizers are also provided, and the boilers will be worked with forced draught on the closed ash pan principle. The engines and dynamos will be placed in the two contiguous rooms, each 195 feet long and 66 feet wide by about 85 feet high. The engine house will be provided with an overhead traveling crane capable of lifting 25 tons.

In the first engine room there will be erected two Ferranti dynamos, each of a capacity of 25,000 lights, or about 1500 electrical horse-power. Each machine will be driven by an independent vertical compound condensing steam engine, the transmission being by 40 cotton ropes. The armatures of these machines are 12 feet six inches diameter, and one inch thick; the speed is 168 revolutions, and the working pressure 10,000 volts. One terminal and the corresponding conductor of the concentric main will be grounded. With so high a pressure as 10,000 volts, it is of course absolutely necessary to make it impossible that any of the attendants could touch a portion of the other circuit. All dangerous parts will therefore be boxed in, and to prevent the possibility of anyone opening the covers of these parts whilst the machines are at work, Mr. Ferranti has adopted an exceedingly ingenious device of locking these covers magnetically by means of the exciting current, the cover itself breaking the exciting current when open. These two machines will suffice for the supply of the lights which have already been taken up by the customers of the company in the city and other parts of London; but eventually these machines will only be used for the day service, the heavy lighting being done by two machines of much larger dimensions, which will be erected later on. These large dynamos will each have a capacity of about 10,000 h. p., and will be direct driven by vertical compound engines of 5,000 h. p., one engine being placed on each side of the dynamo. At first only one engine will be erected to each dynamo, so that the capacity of the station will be about 100,000 10-c. p. lamps, supplied from one machine, the other machine being in reserve. If the demand for current has sufficiently increased, the other engine will be added, and the capacity of each dynamo will thus be brought up to 200,000 lights. Further extension of the plant will be in machines of this type.

The engines are being constructed by Messrs Hick, Hargreaves & Co., Bolton, and the framing of the dynamos by Messrs. Maudslay, Sons & Field, London; Mr. Ferranti manufacturing the electrical parts of the dynamos at his works in Charterhouse Square. A traveling crane of 50 tons lifting power will be provided for the erection of the large steam dynamos. There will be separate condensing engines provided to condense the steam from all the engines. These will be erected in the first engine room, where also the pumps for the hydraulic gear and the exciting dynamos will be placed.

The large dynamos will have 39 ft. armatures, and be direct coupled to the engines, the working speed being sixty revolutions per minute. The current will have a period of 8000 alternations per minute. One of the most interesting parts of the whole undertaking is that which may be broadly described as the distributing plant. The current will be conveyed from the station into local centres in London by concentric mains, consisting of an inner copper tube $\frac{3}{16}$ in. thick, a layer of insulation, and an outer tube $\frac{3}{16}$ in. thick, the diameter of the main being $2\frac{3}{16}$ in. This main is made in lengths of 20 ft., which will be joined by special couplings, suitable provision being made for expansion and contraction. The main will be simply laid into the ground without any other protection than is afforded by the surrounding earth, and the outer conductor will thus be grounded over its whole length, rendering the handling of this main perfectly safe. Where possible the mains will be laid along the railways, but duplicate mains will later on be laid also along the streets. At the local centres there will be transformers bringing down the pressure from 10,000 to 2,400 volts, the standard now adopted at the Grosvenor Gallery station, and the distribution of the 2,400 volt currents will also be effected by concentric mains. Finally these currents will be brought down to 100 volts by other transformers, and only the low tension current will be supplied to the customers. The supply will be by Ferranti meters, which have now been perfected to such a degree that a 200-light meter will begin to register with one lamp. Some very delicate trains of wheels are required for these meters, and as the company had some difficulty in obtaining these trains from the clockmakers in this country, they have sent a member of their staff to America with instructions to buy a complete set of machinery of the type used in the manufacture of Waltham watches, and bring it over. With this machinery the company will be able to turn out some 15,000 meters annually. The Deptford electric light station is certainly the most gigantic work of this class which has yet been undertaken anywhere, the American central stations not excepted; and the greatest credit is due to Mr. Z. de Ferranti, who, unaided by any other engineer, has designed the whole of the works, from the buildings and his huge dynamos down to the mains, transformers, and meters.

1. *Industries.*

ELECTRIC TRAMWAY IN PARIS.

FROM time to time electric traction makes its appearance on the Paris tramways, but vanishes again after a brief spell of apparent success, for some reason not easily ascertained. The latest development of electric tramway work is an experiment which is being carried out on the line between Porte Maillot and the Barrière de l'Etoile by means of storage battery cars, which are very handsomely fitted up, and which have now been running for nearly two months. The battery is of the Faure-Sellon-Volckmar type, constructed by MM. Phillippart Frères, and consists of 144 cells, which, by means of a special switch, can be grouped in various ways so as to supply the current under different pressures, viz., 70, 140, 240, and 280 volts. The total weight of the car with 50 passengers on board is close upon 9½ tons, and the normal power required when running on the level, and at ordinary tramway speed, is 7 h. p.; but when starting and climbing gradients the battery is often called upon to deliver current at the rate of 20 h. p. The total capacity of the battery is 42 h. p. hours, so that the car can remain from five to six hours in service before having to be re-charged. The usual provision is made for charging batteries with the least possible loss of time. The motor is a Siemens dynamo placed under the car floor, and running at 1,000 to 1,200 revolutions per minute. The car is lighted by glow lamps fed from the batteries.—*Industries.*

ENERGY CONSUMED BY VARIOUS ILLUMINANTS.

THE production of light by any means implies the consumption ef energy, and this can be measured in *watts*, or at the rate at which this energy is consumed. A watt is $\frac{1}{746}$ part of a *horse-power*. It is a very convenient and sensible unit of power, and will in time replace the meaningless horse-power.

				watts.
One candle	light maintained by	tallow	absorbs	124
"	"	wax............	"	94
"	"	sperm..........	"	86
"	"	mineral oil.....	"	80
"	"	vegetable oil....	"	57
"	"	coal gas........	"	68
"	"	cannel gas......	"	48
"	"	electricity (glow)	"	3
"	"	electricity (arc).	"	55

The relative heat generation of these illuminants may be estimated from these figures.—*W. H. Preece, F. R. S.* Address as President Mechanical Science Section British Association, September, 1888.

.... THE engineer's electricity is a real form of energy; the speculative philosopher's electricity is a mere vague subjective unreality which is only a mere factor of energy and is not energy itself.—*W. H. Preece.*

.... MENTAL inertia, like mechanical inertia, may be defined in two distinct ways. Inertia is the resistance to motion, that is the English definition; but inertia is also the resistance to stopping,—that is the American definition.—*Professor Ayrton.*

CORRESPONDENCE.

NEW YORK AND VICINITY.

The Bell Telephone Decision.—Meeting of the Medico-Legal Society.—Sale of the Waterhouse Co.—Fires Caused by Electric Wires.—Suit of Electrical Accumulator Co. vs. Julien Electric Co.—The Fourth Avenue Cars.—The Fulton Street Railway.—Increase of Capital Stock of Commercial Cable Co.—Assignment of Edwards H. Goff.—Experiments on the Elevated Roads.—Death of Herrick P. Frost.—Meeting of Board of Electrical Control.—A New Incandescent Lamp.

THE decision of the U. S. Supreme Court overruling the demurrer of the Bell Telephone Co., excited interest in electrical circles largely because an uninterrupted succession of victories had persuaded us that the Bell company's attorneys were invincible. The daily press, always on the popular side, unanimously expressed the hope that this decision would lead to competition in telephone service.

The Medico-Legal Society held its November meeting on the 14th ultimo, at the Buckingham Hotel. The committee appointed at the previous meeting to consider the best method for carrying out the new law providing for criminal execution by electricity, made a report recommending the use of a helmet, the current to enter the body at the top of the head, passing through the brain, and emerging at the back of the neck. They advise an electromotive force of 3,000 volts.

The Westinghouse Electric Co. has followed up its announcement of the control of the Sawyer-Man interests by the purchase of the Waterhouse company.

Defective insulation is alleged to have caused damage by fire to the extent of $10,000 at the Produce Exchange building, November 14th, and the day after a great commotion was caused at the Hoffman House, by crossed wires setting fire to the drapery of a large electrolier in the ladies' dining room.

The suit of the Electrical Accumulator Co. against the Julien Electric Co., has reached a final hearing. The suit was brought in January, 1882, to establish the validity of the patents controlled by the plaintiff. Professor George W. Barker, of Philadelphia, defendants' expert, has submitted an exhaustive report upon the state of the art at the time of the Fauré patent. Professor Henry Morton, and W. B. Vansize are complainants' experts. The defense is based upon the statement that an oxide of lead has been used as a depolarizer in a primary battery as early as 1863, and also in prior experiments of Dr. Van der Weyde and Charles F. Brush.

The storage battery cars of the Julien company, now running upon the Fourth avenue railroad, continue to attract a great deal of attention, and will doubtless do much toward stimulating general inquiry into the various methods of electric traction.

It is stated that the Bentley-Knight conduit will be laid at once for the Fulton street railway. The line will run from the Fulton Ferry across town to the west side ferries from Liberty to Chambers streets.

The Commercial Cable Co. has announced its intention of increasing its capital stock from $6,000,000 to $10,000,000. The prosperous condition of the company, and the demand for further facilities are alleged to justify this increase.

Mr. Edwards H. Goff, who retired from the presidency of the American Electric Manufacturing Co. to assume the management of the *Daily Graphic*, has made an assignment, and the control of the paper has passed into other hands.

The contract for the electric light plant for the imposing *Times* building has been awarded to the United States Electric Lighting Co.

A large amount of experimenting is being carried on with storage batteries with the object of increasing their durability and efficiency, and two new types are about to be placed upon the market.

Mr. H. R. Pierson has leased one of the main salesrooms of the telephone building, 18 Cortlandt street, where the Water Primary Battery Co.'s system will be shown.

Col. C. H. Haskins, of Milwaukee, stopped over in this city a few days upon his return from Europe.

The Manhattan Elevated Railroad has decided to try experimental storage-battery cars upon its switch connecting the Third avenue line with the Grand Central Depot at 42d street.

Notice has been received of the death of Mr. Herrick P. Frost, of New Haven, Conn. Mr. Frost organized one of the earliest telephone exchanges in New England, and retained an interest in a large number of local companies.

The Railway Cab Signal Co. has been experimenting on the Staten Island railroad for over a year, and now claim to have perfected their system.

The joint report of chief-engineer Kearney and electrical engineer Wheeler has been presented to the Board of Electrical Control. The sole cause of the trouble with the conduits is ascribed to the leaks in the steam heating pipes.

A new design of incandescent lamp has been patented by Mr. C. A. Backstrom, an expert employed by the Sprague company. A transparent support is used by which the filament is kept in position. The carbon is applied to the surface of the support in such manner that longer life is claimed than for the ordinary lamp.

An injunction was granted by the Supreme Court, November 19th, against the Board of Electrical Control, restraining the board from interference with the wires of the United States Illuminating Co., until a suitable subway is provided, and from the grant of privileges to the Metropolitan Telephone and Telegraph Co., the Western Union Telegraph Co., and the East River Electric Light Co. A motion to make the injunction permanent will be argued in a few days. The company claim to have been annoyed and discriminated against to such an extent that they have lost 150 subscribers on Broadway.

The Board of Trade and Transportation at its meeting, November 14th, appointed a committee to prepare a bill for the legislature regulating telephone rates.

NEW YORK, November 29, 1888.

PHILADELPHIA.

The Keystone Ordinance.—An Overhead License Refused an Electric Light Company.—Further Displacement of Gas by Electric Light in the Streets.—Hard Work by Telegraphers on Election Night.—Singular Accident to a Lamp Trimmer.—The Welsbach Incandescent Gas Light Company Offers Prizes for Designs of Shades and Globes.—Councils Still Engaged in Regulating Electric Privileges.—Lowell, Mass., Officials Visit Philadelphia to Inspect the City Electrical Department.—A Lecture by Mr. Sprague at the Franklin Institute.

THE Keystone Light and Power Co., whose ordinance giving it the right to lay its wires under a number of streets, has been the subject of some lively discussions in the electrical committee of city councils, astonished the committee recently by sending a communication signed by M. R. Muckle, Jr., as treasurer and secretary, protesting against the committee exercising any jurisdiction in the matter. After reviewing the futile efforts of the company to secure the desired ordinance, the letter said:—

> In presenting this ordinance to your honorable body we do most respectfully protest against all or any jurisdiction of your honorable body in this matter other than what is expressly given by the act of assembly under which the Keystone company is incorporated, to wit: Such regulations as your honorable body may adopt in regard to grades, or for the protection and convenience of public travel over the city streets. We do further most respectfully protest against any and all limitations, conditions or restrictions whatsoever being annexed to said ordinance other than such as are specified by the said act of assembly.

The subject was referred to a sub-committee of three, with instructions to consult the city solicitor and prepare an ordinance protecting the city's interests.

An ordinance allowing the Frankford Avenue Merchants' Electric Light Co. to erect overhead wires along the avenue from Norris street to Alleghany avenue was opposed by Messrs. Boyer and Adams, who held that the wires should go underground, and it went to a sub-committee.

A sub committee of the gas committee of councils met a few days ago to consider a proposal to replace the Siemens' gas lamps in the public squares with burners of improved pattern. Director Wagner suggested that the lamps should be removed and electric lights erected in their place, and a resolution authorizing the substitution was adopted.

Perhaps the hardest worked people on election night were the telegraph operators, who toiled at their instruments in the offices of the various companies, the club houses, newspaper offices, and even in private residences, from 7 o'clock on Tuesday evening until far into the morning hours of Wednesday. The Western Union company furnished the returns to about 65 clubs and a few private individuals throughout the city. Starting in at 7 o'clock P. M., by 3.45 A. M., Wednesday, 175 bulletins had been sent out averaging 50 words each. The service was the best ever given by the company, and the demand for the figures, both in the city and the surrounding country, was far greater than in 1884.

Superintendent C. C. Adams, of the Postal Telegraph Co., said that starting at 6 o'clock Tuesday evening and ending up about 3 o'clock Wednesday morning, that company handled about 200 words of outside telegraphic matter, which, with the Philadelphia returns, reached a total of about 250,000 words. Forty clubs and about 40 private residences in this city were supplied with the bulletins by this company.

Charles Borden, an electric light lineman, had an unusual experience a few days ago, which, however, saved him his life. He was engaged in replenishing carbon points in an arc light at Frankford avenue and Huntingdon street. He lost his footing at the top of the pole and fell headlong towards the pavement, but fortunately a protruding iron step caught in his clothing and held him suspended head downward for half an hour. He shouted for help, and was answered by Policemen Mason and Quick, of the 18th district. They were perplexed for a time to know how he could be removed from his uncomfortable and perilous position, but finally decided to procure a ladder and secure his

release. Ten minutes elapsed, and then the two policemen returned with the needed assistance. They climbed to Borden and carried him to the sidewalk, where it was discovered that the iron step, which doubtless saved his life, had lacerated his thigh. He was taken to the Episcopal hospital thoroughly exhausted.

The Welsbach Incandescent Gas Light Co. has made an offer of five prizes, ranging from $150 to $25, for designs for shades or globes adapted to the Welsbach incandescent light. The company is anxious to secure artistic designs for use specially in private houses. Messrs. Wm. G. Warden, Thomas Dolan, Henry C. Gibson, George Philler and William T. Carter, will act as judges in making a choice. All designs are to be submitted by November 26, next.

The joint committees on councils on the electrical and highway bureaus considered the proposed ordinance for the regulation of the occupancy of streets for electrical purposes. Lawyer Samuel B. Huey, counsel for the Penn and Edison Electric companies, drew the bill, which provides that the same privileges shall be granted to electrical companies as are enjoyed in making service connections with gas and water mains. The bill was approved, with a proviso that the privilege shall not extend beyond March 1, 1889.

A visit to this city was made a short time ago by the mayor and a number of other officials of Lowell, Mass. They came to inspect the workings of the electrical department. The visitors first called upon Mayor Fitler, and were then taken in charge by Chief Walker of the electrical bureau.

Frank J. Sprague, of New York, lectured a few nights since at the Franklin Institute, on "Long-distance Transmission of Power by Electricity."

PHILADELPHIA, November 16, 1888.

BOSTON.

The West End Railway Company.—Meeting of the Society of Arts.—Sale of the Newton Electric Light Co.—Explosion in a Conduit Man-hole.—The Agitation Against Overhead Wires.—The Electric Club.—The Flurry in the Stock Market Caused by the Supreme Court Decision in the Government Telephone Suit.—Quarterly Statement of the Erie Telegraph and Telephone Co.—Monthly Statement of the American Bell Telephone Co.

THE West End Railway Co. expect to have a few electric cars running by the first of December. The petition presented to the railroad commissioners met with no opposition, and the city authorities of Cambridge have recently given permission to construct and operate a surface electric traction system to the West End company. The privileges granted by the City of Cambridge oblige the street railway company to place and maintain an electric light upon each post, the posts to be protected by suitable iron or granite curbing at the base.

The 37th meeting of the Society of Arts, was held October 25, at the Massachusetts Institute of Technology. Mr. Charles A. White, of Boston, exhibited and described the eco-magneto watchman's clock. Mr. W. E. Gump, read a paper upon the Writing Telegraph, which closed with practical demonstrations of the method of operation of the system.

The Newton Electric Light Co.'s plant has been sold to the local gas company, at a price said to be $125,000. This action ends the contest between the two companies over the city lighting contract.

An explosion at the corner of Washington and Boylston streets in an Edison man-hole has been the subject of considerable discussion in the Boston papers. The heavy iron cover was hurled high in the air alighting upon and breaking the glass sidewalk in front of Sage's trunk store. District Manager Edgar's opinion is that the trouble was caused by sewer gas becoming ignited by a spark from the wires.

The agitation against overhead wires is being renewed with increasing vigor. Captain Flanders, superintendent of the fire alarm, reported at a conference of the heads of departments at the mayor's office that there were at least 400 miles of overhead wires in this city. Mayor O'Brien asked what would be the result if the legislature passed a law ordering all wires underground. Mr. Flanders replied that it would seriously interfere with the proper service of the wires. The council has authorized the special committee to visit New York and other cities for the purpose of examining the different conduit systems.

The Wednesday evening "informal talks" of the Electric Club have been continued. Recent papers were those of Mr. J. C. Wilson, upon the Police-Alarm System, and T. W. Sprague, upon Electric Applications to Mining in the West.

The board of aldermen have passed over the mayor's veto the order giving valuable privileges to H. E. Cobb, R. M. Pulsifer, and H. E. Chapman for constructing an underground conduit system. The franchise, however, is not exclusive.

The recent decision of the United States Supreme Court overruling the demurrer of the Bell company, caused a commotion in the stock market, the stock selling off to 187 from 207, but rallied later to 200. The heavy selling was largely due to a misapprehension of the purport of the decision.

The Erie Telegraph and Telephone Co. directors have declared a regular dividend of three-quarters of one per cent., and an extra dividend of one-half of one per cent., both payable November 12, to stockholders of record at 2 P. M. November 5, the stock books being closed from the latter date until November 12. The statement of operations for the quarter ended September 30 and the first half of the current fiscal year is as follows:—

September—	1888.	1887.	Increase.
Gross earnings	$168,361	$153,795	$14,566
Gross expenses	109,054	100,780	8,274
Net earnings	$59,307	$53,015	$6,292
Construction	8,847	12,350	*3,503
Balance	$50,460	$40,665	$9,795
Dividends	36,000	36,000	....
Surplus	$14,460	$4,665	$9,795

*Decrease.

The number of subscribers connected July 1, 1888, was 10,747; added during the quarter ended September 30, 285; total connected October 1, 1888, 11,030, against 10,299 October 1, 1887; increase in one year, 731.

The statement of the output of telephones by the American Bell company for the month ended October 20, and the fiscal year to date, is as follows:—

October--	1888.	1887.	Increase.
Gross output	4,140	3,689	451
Instruments returned	2,145	2,213	*68
Net output	1,995	1,476	519
Dec. 21 to Oct. 20			
Gross output	45,800	44,340	1,460
Instruments returned	18,947	22,028	*3,081
Net output	26,853	22,312	4,541

*Decrease.

BOSTON, November 17, 1888.

CHICAGO.

The Chicago Telephone Co. and the City Council; the Company Declines to Accept the Ordinance Reducing Rates; its Reasons Presented in a Letter to the Council.—Judge Blodgett's Decision Against the Cushman Telephone Co. in the Indiana Case.—The Cushman Company Petitions for a Re-hearing of the Infringement Suit Decided Last July.—An Electric Lighthouse on the Lake; The Fog Bell Worked by an Electric Motor.—Installation of a Baxter Motor.—The City Lighting Plant.—The Rapid Introduction of Motors on the Edison Circuits Expected.—The Chicago Electric Club; a Paper by Mr. C. C. Haskins.—Locomotive Engineers Ordered to Provide their Watches with Anti-Magnetic Shields; they Protest and May Strike.—Electrical Business Outlook.—The Van Depoele Company.—Professor Badt's Return from Europe; he accepts a position with the Western Electric Co.—Incorporations and Business Notes.

IT was mentioned in the Chicago letter of last month, that the city council had passed an ordinance for the regulation of the business of the Chicago Telephone Co. A new schedule of rates, which was the principal feature of the ordinance, reduced rentals from $125 per year to $95 the first year and $85 each succeeding year, or $75 on three years' contracts. It was the general belief that the company would not accept the ordinance. Predictions proved correct. At the city council meeting of November 12, a communication from the president and directors of the telephone company defining their position in the matter was presented. They attempted to show why it is that telephone service is more expensive in cities than in smaller places. It does not seem to be a difficult subject to grasp, but the Chicago company finds it necessary to combat the idea that "the telephone companies are the only concerns which sell higher at wholesale than at retail." The document is interesting to all telephone companies because it attempts to elucidate this point. The essential part of the communication follows:—

To improve their service and to give the public the best telephonic conveniences known to the art, we have expended over $1,000,000. As a matter of fact, all of our construction has been made upon the streets of the city with the express consent and often under the direction of the officers of the city.

October 15, last, the city council passed an ordinance defining the rights of the rights of the Chicago Telephone Co., in which ordinance they inserted a provision that said Chicago Telephone Co. shall not charge for the use of each telephone connected with its exchange more than $85 for each year subsequent to the first, and shall contract for three years' service with any one party at the rate of $75 per annum, which limitation prevents our acceptance of the ordinance. The present differences between the city and ourselves arose, we believe, on account of a misapprehension as to our rights in the city, the amount of free telephone service we render the city for these rights, and the fairness of the price we charge our patrons for the service rendered them, which misapprehensions we would like the opportunity to correct.

As to the first of these questions, we have already referred to our rights derived from the city.

As to the second, the city has, under its grants to the company, the right to demand certain free telephone service. This right is conceded by us, and the service given the city. After this engagement was entered into, one of your

citizens invented and introduced what is known as the police patrol system, for which we voluntarily made a special arrangement with the American Bell Telephone Co., whereby we have been enabled to rent you telephones for the use of the patrol system at a lower price than we furnish them to any other customer for similar service. Including the above rebate, with the exchange and private lines, which we are furnishing the city without any charge, we are making a concession of over $10,000 per annum in excess of the requirements of your ordinance.

A list of cities with the rental charged by the companies is presented, after which the letter continues as follows :—

In the ordinance passed October 15, the city undertakes to legislate upon the matter of rates to be charged by the telephone company, a subject which our counsel advise us is not covered by the city's charter, and that for that reason the ordinance is void.

This company is not disposed to stand only on its legal rights, but is willing to make a fair adjustment of the differences between us, for which purpose we will be pleased to discuss the questions with any committee to whom you may refer the matter.

It has been, and is, our policy and our endeavor to conduct the difficult business of this company honestly and with fairness to our subscribers. No effort or expense has been spared to secure the best mechanical devices, constructions, and operators.

We submit, with due respect, that we know of no good reason why this interest should be singled out by the city and weighted with burdens imposed on no other corporate interest in Chicago.

In estimating the fairness of our charges to the public, it seems to be generally forgotten that we pay more to a railroad to carry us 1,000 miles than 100; the grocer more for a barrel of sugar than a pound; more for an advertisement in a newspaper of 100,000 circulation and published daily than of 10,000 circulation, with only a weekly edition. We say it seems to be generally forgotten, because we are denied an application of the same principles which govern in the cases above mentioned. It is unquestionably true that smaller places charge less per annum to each subscriber than we do, but it is equally true that less is furnished, and that each service or "connection" costs more in those places than here. The average cost of our service to the subscriber last year in this city was a fraction under two cents per connection.

The only other means of communication which approaches this in cheapness is the postal-card, where a brief question and answer may pass between two people for two cents, using at least 12 hours' time.

The finance committee of the council subsequently endeavored to bring about an adjustment of the controversy but failed. The president of the telephone company offered to pay as consideration for the corporate privileges 2½ per cent. of the gross income, but he refused to make any reduction in rentals to subscribers. The council is rather inclined to test the matter in the courts. The legal department is confident that a decision affirming the right of the city to regulate charges can be obtained from the Supreme Court.

In the suit brought by the Bell company against the Cushman Telephone Co. for infringement for operating telephone exchanges in Indiana, Judge Blodgett has handed down a decision in favor of the plaintiff corporation. In his decision Judge Blodgett says :—

Defendants are engaged in furnishing telephone service and operating exchanges in several cities in Indiana, and insist that an injunction should not be granted on this motion, because a few years since the complainant's grantees or licensees established telephone accommodations in some, if not all, of these cities, but withdrew therefrom after the passage by the legislature of Indiana of an act limiting the rates of charges for telephones and for telegraphic services.

I do not think the fact that the complainants, licensees, or grantees have withdrawn their telephonic accommodations from these cities furnishes any excuse or defense for the infringement of these patents by these defendants. The law gives the owner of a patent the exclusive right to the use of the device covered by his patent, and the rule that because the patentee or owner of a patent cannot agree with those who wish to use his device as to the price to be paid for such use, authorizes another to pirate upon the patent with impunity, would be destructive of patent property.

In reference to the validity of the Indiana statute, the court says :—

Counsel for the defendants insist that the main question involved in this case is the validity of the Indiana statute regulating the charges of telephone service, but I do not consider that question involved in this motion. It was stated on the argument of this motion, and I doubt not truly, that this question is in the way to be presented at an early day to the Supreme Court of the United States, which is the proper tribunal to pass upon it. But it would be strange indeed if, where A is the undisputed or adjudged owner of a patent which B wishes to use, but B is not willing to pay the amount demanded by A for such use, therefore C can infringe the patent and supply B with infringing machines and not be restrained from so doing, when the validity of the patent and infringement are clear.

The Cushman company took the position that Judge Blodgett had decided in the case of Hoe against Knapp, that a patentee who did not put his invention into use was not entitled to an injunction. On this point Judge Blodgett found as follows :—

I think, however, that the case there made was another and widely different one from this, runs the decision. There the patentee had never made a machine nor put his patent into use; he had simply locked it up, so to speak, and kept the public from the benefit of it. Here the patentee has put his patent into extensive use and is receiving a large income for such use at rates agreed upon between the owners of the patents and the users; so that this complainant does not stand as the complainant did in the case cited.

The Cushman Telephone Co., of Chicago, filed a petition November 2, for a rehearing in the general infringement suit, in which it was beaten at all points by the Bell company last July. The petitioners allege that in his decision Judge Blodgett misapprehended material facts in proof; that he failed to consider many important facts; had drawn conclusions not warranted by facts, and had erred in the application of the law. It is also alleged that further material evidence will be forthcoming.

The first electric lighthouse on the lakes is now to be seen in Chicago. The installation is at the water-works crib, half a mile north-east of the North Side pumping station. The lighthouse is 70 feet in height, and the lamps are surmounted by a circular glass lantern. The lighting apparatus consists of 24 32-c. p. lamps, mounted with a circular reflector. The light can be seen eight miles away. The fog bell is 600 pounds in weight, and is struck by a 24 pound hammer, which is raised and dropped eight times a minute by a revolving cam connected to a quarter horse-power electric motor. The motor and lamps are operated by switches in the dynamo room of the water-works. The current is conveyed to the crib by five lead covered cables.

The Chicago department of the Baxter Electric Motor Co., has installed in Augustana College, at Moline, Ill., a one horse-power motor for blowing the organ in the institution. The mode of operating the motor is extremely simple. The motor switch is connected to a small cable, one end of which is attached to the movable part of the bellows. To the other end is fastened a weight. As the bellows are filled with air the weight will close the switch. As the bellows are emptied the cord is drawn in the opposite direction and the motor is set in operation. The motor is on an arc circuit.

It is now predicted that the city electric light plant will be put in operation on Christmas day. It was prophesied that the work would be completed weeks ago, but one obstacle after another was encountered which necessitated the postponement of the opening day. The city officials say that everything is now in such satisfactory condition that they feel warranted in making another prediction.

With the extension of the Edison circuit in the city comes a widened field for the employment of motors. Unless predictions fail, installations of motors will soon be numerous. The Edison company has reduced its charges for power service. It is more than probable that motors will be employed in running high speed elevators in several new buildings.

At the meeting of the Chicago Electric Club, October 29, C. C. Haskins read a paper on "Universality of Vibrations." The subject was thoroughly discussed by Mr. Haskins, and his treatment of it was full of interest and suggestion.

The locomotive engineers of the Northwestern railroad have been ordered to provide their watches with anti-magnetic shields. They are protesting, and it is asserted that if the order is rigidly enforced a strike may be declared.

The business outlook for the electrical trade in Chicago seems to be most hopeful. Orders in all departments are large, and less business is transacted for honor. The fall trade has been large and the outlook for the winter is encouraging.

The Van Depoele company, of Chicago, has completed its first incandescent dynamo, and has sold it to the Ferracute Machine Co., of Bridgeton, Conn. It is a 200 light machine. Hereafter incandescent lighting will form an important feature of the Van Depoele company's business.

Professor F. B. Badt, who was formerly connected with the Chicago office of the United States Electric Lighting Co., has returned to the city after a six months' visit in Europe. He has accepted a position with the Western Electric Co.

The Gas and Electric Light Co., of Alton, Ill., has been incorporated. The capital stock is $60,000, and the incorporators are Alva E. Campbell, John Watt, and Levi Davis, Jr.

The Decatur (Ill.) Electric Street Railway Co., has been incorporated by E. T. Martin, C. M. Barclay, and F. Sargent. The capital stock is $100,000.

The Cutting Electric Alarm Co., of East St. Louis, Ill., has been organized with a capital stock of $8,000, by W. H. Cutting, B. C. Graham, and B. Gratz.

The Consolidated Electric Light and Power Co., of Aurora, Ill., has been incorporated with a capital stock of $50,000. The incorporators are, I. B. Copley, Howard Knowles, and I. C. Copley.

The Shaw Electric Crossing and Advance Signal Co., of East St. Louis, Ill., has been incorporated. Capital stock, $1,000,000; incorporators, W. P. Shaw, A. X. Mackey, and John B. Livingston.

CHICAGO, November, 20, 1888.

POINTERS.

. . . . PUTTING a conservative drag on the wheels is a very good precaution to take when going down hill, but it is out of place in the up-hill work of progress.—*Professor Ayrton.*

. . . . 110,000 miles of cable have been laid by British ships, and nearly £40,000,000 of British capital has been expended by private enterprise in completing this grand undertaking. A fleet of 37 ships is maintained in various oceans to lay new cables, and to repair breaks and faults as they occur.—*W. H. Preece.*

. . . SOME people fancy because the answer to that oft repeated question "What is electricity?" not only cannot be given exactly, but can only be guessed at in the haziest way, even by the most able, that therefore all electric action is haphazard. As well might the determinations of a ship's latitude at sea be regarded as a mere game of chance, because we have not even a mental picture of the ropes that pull the earth and sun together. —*Professor Ayrton.*

LETTERS TO THE EDITOR.

Notice to Correspondents.

We do not hold ourselves responsible for the opinions of our correspondents.
Anonymous communications cannot be noticed.
The Editor respectfully requests that all communications may be drawn up as briefly and as much to the point as possible.
In order to facilitate reference, correspondents, when referring to any letter previously inserted will oblige by mentioning the serial number of such letter, and of the page on which it appears.
Sketches and drawings for illustrations should be on separate pieces of paper.
All communications should be addressed EDITOR OF THE ELECTRICAL ENGINEER, 11 *Wall street, New York city.*

LEAD ENCASED CABLES.

[100.]—I HAVE read with much interest the letter of Mr. David Brooks (99), printed on page 543, your November 1st issue.

Some time ago, about two and one half years, the electric light company in which I am interested required a cable for crossing a river. I made some inquiries at that time regarding the best cable to be used for that purpose, and found that lead covered cables with paraffine insulation had given good results where numerous other forms of cables had failed. My company ordered such a cable, armored with iron wire, and it has given good results. There has been no failure of the cable, and to all appearances it is as good to-day as when first laid. I happen to know that in three other cases at least this same style of cable has given equally good results, for a period of time longer than that for which I have used the cable.

I am about to order some more electric light cable for another location. I do not know much about the theory which Mr. Brooks talks about, but on the other hand I seem to have the advantage of him in the little experience I have had with lead encased cables.

Don't you think I am safe in being guided by my experience?

November 10, 1888. W. M. C.

LITERATURE.

REVIEWS.

Materialen für Kostenvoranschläge Electrischer Lichtunglagen. VON ETIENNE DE FODOR. Wien, Pest, Leipzig: A. Hartleben's Verlag.

HARTLEBEN'S Electro-technische Bibliothek has found eager readers in this country because its volumes contain so much that is of importance to the practical electrician. The publishers of the series are fortunate in securing writers who are successful in apprehending and meeting the wants of this class. This thirty-ninth volume is no exception in this particular. In the 224 pages which are devoted to the enumeration and description of the materials on which estimates of the cost of electric lighting plants are based, there is little that is superfluous, and yet the lists of apparatus appear complete.

Considerable attention is given to a description of the Edison "three-wire" system. As the estimates of the cost of such a plant have to be modified to suit its peculiar conditions, such a description is, perhaps, not unnecessary. The first part of the book is, in a measure, preliminary and is descriptive of dynamos, storage batteries, incandescent and arc lamps, and the various other parts of an electrical equipment. For the most part the matter is sufficient and at the same time concise; but the information regarding dynamos is somewhat meagre in respect to the number of manufacturers whose machines are described.

The types of the Edison, Gramme, Siemens, Halske and a few others are given in full; but several kinds are conspicuously absent. The part concerning cut-outs and switches is particularly good, and is copiously illustrated.

The main part of the book is devoted to lists of apparatus for different kinds of plants. Here is shown considerable care in details. In the specifications for a central station, there is given, not only the aggregate of hours of lighting for the year, but tables of hours for each month.

On the question of comparative economy in the "three-wire" and alternating current systems, the author decides in favor of the latter for distances above 3,000 feet. For less than that he recommends the former. The question of the comparative economy of several small steam engines and a single large one for a central station, is settled in favor of the former—a conclusion that experience in this country seems to justify. The subject of isolated plants is pretty thoroughly treated. The theater, the man-of-war, the hospital, the concert garden, the railroad passenger coach, and many kinds of factories are all equipped (on paper) with the requisites for electric lighting.

The book can be recommended to the student in electrical engineering, as giving him an idea of one of the problems he will have to solve; to those contemplating the installation of an electric lighting plant, as showing them what expenses they will have to meet; and to the electrician, for whom all tables and data such as are here collected have their use.

RECENT PUBLICATIONS.

The Steam Boiler Catechism; A Practical Book for Steam Engineers, and for Firemen, Owners and Makers of Boilers of Any Kind. By Robert Grimshaw, M. E. New York: *D. Van Nostrand and Practical Publishing Co.* 16mo., cloth, 402 pp. Price $1.00.

Die Erzeugung und Verteilung der Elektrizitat in Zentral-Stationen. Von Dr. Martin Krieg. Band II. Magdeburg, 1888. *A. & R. Faber*, sm. 8vo., paper, 371 pp.

CATALOGUES AND PAMPHLETS RECEIVED.

Pocket Hand-book—Standard Underground Cable Co. The makers of electrical cables and wires vie with one another in the issue of manuals containing a variety of useful information in addition to their trade announcements and price lists. The recent hand-book sent out by the Standard Underground Cable Co. supplements its lists of wires and cables, with prices, by 25 pages of useful information, bearing, for the most part, upon matters relating to electric conductors. A brief telegraphic code specially prepared for use in business correspondence with the company, is followed by a series of useful tables, and rules, interspersed with many facts and items convenient for the practical worker to have at hand. Among the handy tables are the following:—Fractions of an Inch Expressed in Mils (from $\frac{1}{64}$ to $\frac{1}{2}$ inch); Feet in Decimal Parts of a Mile; Wiring Table for 50 Volt Lamps, 2% loss; Melting Point, Specific Gravity and Conductivity of Various Materials; Table of Weights and Measures—besides the usual wire gauge tables. The diagram illustrating the circular mil on page 35, will be found useful as a sort of object lesson, by linemen and others not fully conversant with the somewhat confused nomenclature employed in practice, and who desire to understand the mutual relations of the various terms used. The hand-book concludes with working directions for placing, splicing and connecting electric cables.

The Seafert Electrical System, Light and Power. A pamphlet thus entitled reaches us from Chicago, and is issued by William Seafert & Co. What this "system" is does not appear in the pages of the circular, but what it is going to do is set forth with much confidence. Some particular mode of regulation for dynamos appears to be the basis of the Seafert system. The reader is told how the regulation is *not* accomplished, at considerable length, but, as to how it is done has to content himself with the information that "the simple tilting of a delicately poised lever effects the entire regulation without loss or waste of energy." Further quotations are the following:—"The principle is adapted equally to the direct or alternating current." "The energy required in the external circuit is made the limit of output in the generator." "The principles underlying the Seafert system make it possible to dispense with all devices which absorb current energy, but yield no equivalent in useful work." Everybody interested in electrical distribution will readily agree that "this is what we long have sought, and mourned because we found it not."

We are in receipt of a copy of the Report of the Special Public Lighting Committee, of Detroit, Mich.,-sent us by Mr. Fred. H. Whipple, who compiled the information by direction of the committee. The report contains much matter of interest upon the following subjects:—"Cost of Public Lighting in other Cities by the Rental System," "Cost of Lighting in Cities which Own and Operate their Plant," "Methods of Electric Street Lighting," "Underground Lines."

The report includes letters received from the executive officers of a large number of companies who have tried various systems and devices, and the results given are both interesting and instructive. Mr. Whipple has also made use in his report of the proceedings of the National Electric Light Association at several conventions—printing several papers relating to underground work, with copious extracts from the discussions of the Association.

A Directory of Electric Arc Lighting Plants in North America, issued by the National Carbon Co., of Cleveland, Ohio, contains in 92 octavo pages, a convenient list of arc plants arranged by states, territories and provinces alphabetically. Lamps are classified as commercial, street and isolated. The National Carbon Co. request all who are interested in arc lighting to send them full information in the way of correction or addition, for use in a subsequent edition of the directory. They desire it to be accurate and complete.

POINTERS.

.... IT is so easy to be wise when criticising the past, so difficult to be wise when prospecting the future.—*Professor Ayrton.*

.... PEOPLE are singularly callous in matters affecting their own personal safety; they will not believe in mysteries, and they ridicule or condemn that which they do not understand.—*W. H. Preece.*

.... THE means of ready intercourse and of communication, and the means of easy travel, are all due to the application of science by the engineer. Is not, therefore, his profession a beneficent one?—*Sir Frederick Bramwell.*

.... I ONCE ventured to predict that unless some substantive improvement were made in the steam engine (of which improvement as yet, we have no notion), I believed its days, for small powers, were numbered, and that those who attended the centenary of the British Association in 1931, would see the present steam-engines in museums, treated as things to be respected, and of antiquarian interest to the engineers of those days, such as are the open-topped steam cylinders of Newcomen and of Smeaton to ourselves. I must say I see no reason, after the seven years which have elapsed, to regret having made that prophecy, or to desire to withdraw it.—*Sir Frederick Bramwell.*

.... I COULD write you volumes on the improvements which I find made, and making here, in the arts. One deserves particular notice, because it is simple, great, and likely to have extensive consequences. It is the application of steam, as an agent for working grist-mills. I have visited the one lately made here. It was at that time turning eight pair of stones. It consumes 100 bushels of coal a day. It is proposed to put up 30 pair of stones. I do not know whether the quantity of fuel is to be increased. I hear you are applying the same agent in America to navigate boats, and I have little doubt, but that it will be applied generally to machines, so as to supersede the use of water ponds, and, of course, to lay open all the streams for navigation —*Thomas Jefferson.* Letter to Charles Thomson, dated London, April 22, 1786.

NEWS AND NOTES.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

MEETING OF NOVEMBER 13, 1888.

THE American Institute of Electrical Engineers met on the 13th of November at 8 P. M., at the College of the City of New York. Mr. Ralph W. Pope, secretary, announced the receipt of a letter of regret from the president, Mr. Edward Weston, saying that he would be unable to be present.

On motion of Mr. T. C. Martin, Captain O. E. Michaelis was chosen chairman for the evening. Captain Michaelis, on taking the chair, said :—

Gentlemen, I am very much obliged to you for this mark of your kindness. At this early meeting of the current working year, we may especially congratulate ourselves upon having papers presented to us in so desirable a manner. We have here, perhaps for the first time in our history, an opportunity of illustrating papers properly, and I am sure we are all very thankful indeed to the officers of the college who have extended these facilities to us. As is our custom, no business will be transacted this evening except the reading of the papers and the discussion thereupon. The first paper of the evening is on "The Geyer-Bristol Meter for Direct and Alternating Currents," which the author will read. It is needless for me to introduce this gentleman to you. He is a graduate of this institution, and for the past 20 years has been pupil and coadjutor of Professor Morton, of the Stevens Institute.

Professor Geyer then read his paper (see page 571), and made the following remarks in addition :—

The compound bar in its simplest form consists of two strips of metal soldered for their whole length and flatwise, these two metals having different coefficients of expansion. In the bar I have, the metals are brass and steel. The brass expands more than the steel, consequently the bar bends, becoming convex on the side of the brass. Thus I have here a bar which is practically straight: I heat it for a moment and the bar is very notably bent. If such a bar were heated by electricity it would also bend. The disadvantage of an instrument constructed in this way would be that it would also be a thermometer, and to make it simply a current meter would require the introduction of troublesome corrections.

I will just for a moment call your attention to the instrument. You will see it has been recording for the time you have been here. By the kindness of the authorities here I have been furnished with current as you see, which here supplies a rack of lamps, and as I turn the lamps off and on you can notice that the pointer gradually goes down or up, leaving its record. The pointer does not respond instantly to changes of current, but as in actual use this record is spread over days, and in fact probably over weeks and months. This, I think, would not be a serious inconvenience. The clock that we have here at present causes that dial to rotate once in 12 hours. Of course, we might have a clock rotating faster or more slowly. If it had been convenient, I should have gotten one where the dial moved much more rapidly.

The Chairman—Gentlemen, I am sure we are all very grateful to Professor Geyer for his clear and able exposition. The subject is now open for discussion. It is understood, I hope, that the discussion is not limited to the members of the Institute, and that we would be very glad to hear from any of our friends who are with us this evening.

Professor Mayer—I was going to ask one question merely to illustrate farther what I have heard, that is as to the linear quantity separated from the plane.

Professor Geyer—I have not estimated or tried to measure exactly what that quantity is. Our idea is to bring the wire of course very close to the centre line of the strip, but of course not going sidewise with the centre line of the strip. I have several bars here finished right off, passing the current through which the gentlemen are at liberty to examine. If you will give me just a moment, I might illustrate by drawing the relative position of the strip and wire. This (making a sketch) represents the strip. Let this represent the wire and then let this part be insulation. I have made it here unnecessarily thick. Then we have another portion of the strip. This then represents the strip, this represents the cross-section of the wire. This insulation I have made unnecessarily thick. That portion of this strip which has been driven to the rear side will, when the dies are brought down, pinch it on that side, whereas that portion of the strip will pinch it on the other side. I might state in an incidental way that these pieces of the strip are made unequally wide by the dies, so that as it runs down bringing pressure they are stretched up one a little more than the other, showing the wire outside of the centre.

Dr. Wheeler—I would like to ask Professor Geyer what is the effect of changes of atmospheric temperature on the instrument.

Professor Geyer—We have experimentally tried to find out whether atmospheric changes of temperature did affect it by taking it in the winter time from an ordinary heated room into a hall-way or passage-way where the temperature was below freezing, and then passed the same current as current by another instrument through it without being able to detect any difference in the reading. It is the difference of the temperature in the two bars which counts, not the actual temperature of either one.

Mr. F. B. Crocker—I would like to ask Professor Geyer if the moisture in the atmosphere had anything to do with it. The same question arises in regard to the Cardew voltmeter. I have never heard that question answered. Now every moist day, for example, this bar which is intended to get hot, loses its heat more quickly than it does on a very dry day. In other words, would the difference in temperature be greater on a dry day than on a wet day?

Professor Geyer—On that point we have not made any experiments. I should judge from general principles as it is simply the difference of temperature between the two bars, that the case would be analogous to the case that I mentioned before, putting the instrument into the warm room and then into the cold room; the moisture in the atmosphere if it has any effect, being simply only equivalent to increased heat or increased cold around the instrument. Experimentally I could not say what the results would be, although I should imagine they would be negative.

Mr. Carl Hering—I would like to ask whether it would make any difference with this instrument whether the current were direct or alternating.

Professor Geyer—It would make no difference whether the current were direct or alternating. What we measured is the heating effect of the current. We say an alternating current is equal to a continuous current for all practical purposes when it produces the same heating effect.

In answer to a question by Dr. Van der Weyde, Professor Geyer said :—

The instrument as shown here is intended only as an ammeter, although we believe a volt meter can be made. In this case it is necessary to introduce very high resistance. That we think we can accomplish by causing the current in one of the parts not simply to come down but to go back and forward a very great number of times. Thus instead of the wire which grows hottest in our present arrangement, we take a very fine wire—which of course it must be to make a voltmeter of—and bend it backward and forward a great number of times, and then lay that as a flat disc upon the other strip. (Illustrating.) The other strip having the current passing through it or not passing through it as may be desired.

I found it would be heated anyhow by its proximity to the wire here; but there would be no difficulty, of course, in passing the current through this strip in addition to passing it through, zig-zag, back and forward.

Dr. Van der Weyde—The objection to using the principle of expansion by heat as a voltmeter, is that currents of a very small number of amperes have no heating effect. It is the amperes which cause the heat; the electromotive quality does not. For instance, in the old fashioned friction machine we have plenty of force; the electromotive force is very great. Professor Mayer, in a lecture at the Stevens Institute, demonstrated that the number of volts of a static machine went up into the thousands. A volt meter based on the expansion principle has a very limited range, and in fact it is but a metallic thermometer calibrated for volts. If you calibrate it for amperes it may be very correct. There is no doubt of it because the amperes cause the heat.

Professor Geyer—Whether we say that it is the current that heats the wire or the electromotive force that heats the wire, to my mind is a mere question of words, because we ordinarily understand that it is the electromotive force that makes the current, so we could say the current heats or the electromotive force heats.

The question as to whether a volt meter will record so many volts, or so many volts, is to my mind simply a question of proper adjustment of parts. Thus, for instance, at the Stevens Institute we had occasion last summer to measure directly the electromotive forces of a Westinghouse alternating machine. We wanted to measure if possible directly without any multiplying devices, volts say from 10—go up to 500—we therefore constructed a volt meter sufficiently long—in fact it was two stories high, and we had no difficulty whatever in getting very large deflections for 10 volts—that is as low as we cared to go, and we made our pointer go around nine times for 500 volts. To make no mistake in counting the nine turns we had a secondary dial, which, as on a common clock, rotated one division for each revolution of the other dial.

Mr. C. O. Mailloux—I would like to ask Professor Geyer what is the rule or law, or function of getting the deflection of the strip with the rate of current.

Professor Geyer—In some respects it may be unfortunate that the deflections are not proportional to the currents. It would hardly be expected. As we all know the heating effect varies as the square of the current, so if I double my current I have four times the heat produced, but then the bars will lose their heat much more rapidly when they are at a higher temperature. The deflections are not then as the square of the current, but as some intermediate function. I have plotted out some curves, and if I

had thought of it I might have drawn them on the board. I have not a curve here, but I might represent it, making a guess at it. Let the horizontal line (referring to a sketch) represent amperes, and let the vertical line represent deflections. If there were no increased loss of heat due to increased radiation from increased temperature, then, of course, our curve would be one rising quite steeply, and of course if the deflections are proportional to the current, our curve would be a straight line. As a matter of fact it is a curve between a straight line and the curve which rises as steeply as the amount of heat due to the law of radiation would require.

In reply to a question by Mr. Walcott, Professor Geyer continued :—

It can be seen by noting the relative distance of the concentric circles what the rate of increase is for increased current. You will at once notice at the outside of the disc that the distance between two concentric curves is greater there, that the instrument grows more and more sensitive as the amount of current on it is increased.

Mr. Crocker—I would like to ask Professor Geyer one question, which I think has an important bearing on all meters, and that is as to the amount of current consumed by it compared with the amount of current that it measures—that is to say, the efficiency of the meter. I think these meters working by the heat produced —for example Professor Forbes' meter, and to a certain extent the Cardew meter, consume rather a large quantity of current in proportion to the current that they measure. For example, when 10 lamps are in circuit—we say 10 amperes—I would like to ask Professor Geyer what the drop over the meter would be in volts.

Professor Geyer—I agree with Mr. Crocker that the question of resistance is a very important one indeed, and we have aimed to keep the resistance of the ammeter low. The resistance of the bars which are here exhibited, is about .06 of an ohm. We believe it could be brought much lower, possibly by using other metals. Probably the length of the bar might also be much shortened. When I tell you the resistance of the instrument is so much, you can calculate at once for any given current the loss of energy in the meter.

Dr. Wheeler—What is the ampere capacity of that .06 strip?

Professor Geyer—That strip will carry currents up to 20 amperes and possibly greater. We have not urged it beyond that point. It can be made to any capacity by making the cross-section of the pieces greater.

In the Cardew instrument, of course, great resistance is not an objection. It has always to my mind been one objection to the Forbes' meter, that it consumes relatively a large amount of energy. He uses a very small proportion of the heat produced to operate a little windmill. We may be said to use the whole heat produced.

Mr. Walcott—With regard to the volt meter which was drawn on the board, the reason why I asked my question was because it would require considerable length of wire, and I should judge the self-induction would be very high. That seems to be the trouble with using a straight wire.

Professor Geyer—I think if the wire were wound zig-zag, the self-induction would, for that very cause, be eliminated.

Dr. Moses—I regret to say, gentlemen, that I came late this evening. There are one or two questions that may be a little at random, but they are simply through ignorance, not having heard the earlier part of Professor Geyer's lecture. Is there any superior advantage in having different radiating areas of the same metal over different radiating areas of different metals?

Professor Geyer—The great point is that we have two strips whose co-efficients of expansion are equal, so that simple atmospheric changes shall not cause the bar to deflect. If then you select two different metals, which however have the same co-efficient of expansion, it will not alter the action of the instrument. The object of getting more radiating surface is to get a greater difference of temperature between the one conductor and the other conductor.

Professor Mayer—The whole question resolves itself into this: The instrument comes very soon into equilibrium, although we may have different metals, so that it takes three times as much heat to heat one as the other. The radiation of the instrument will depend entirely on the difference between the plate and the surrounding surface; so that this question does not enter into consideration, in reference to the action of the instrument, so far as I can determine.

Dr. Moses—One farther question. Do you believe it is possible to keep the surface at the same equal degree of polish, and in that way to be able to get equal ratios of radiation? Take german silver; the oxidation that will take place upon it from the increased radiating area of one side, may in that way affect its accuracy after a while, may it not?

Professor Geyer—I think it would affect the rate of variation to a slight extent. We propose to use such a cross-section that the wire shall never lose its polish from simple heat generated in it. It would thus only lose its degree of polish gradually if subjected to severe treatment from without—say strong acid fumes. Ordinary atmospheric changes do not seriously affect german silver.

Dr. Moses—In the case of alternating currents have you considered the electric density, so to say, of the conducting body in relation to the differences of areas. That is a question that has recently been brought forward. Have you had time since its suggestion to look into the matter.

Professor Geyer—I must confess my ignorance, and ask the Doctor to explain what he means by electric density. Then perhaps I shall be able to answer.

Dr. Moses—I mean by that the fact that in conductors of different areas of cross-section there have been found to be certain parts of them that by an electromotive force set up within the body of the conductor itself it has been found to be like the central part of rods in mechanics in strains, that do not have the same ratio of conductivity owing to the sudden alternations of the current; the current not seeming to be able to permeate as it were to the centre. This difference in area might in some way or other affect the amount of current that would pass over the conductor wire and surface, and in that way somewhat affect the heat radiation.

Professor Geyer—I thank the doctor for his clear explanation. I can only answer it as far as this—that I have lit up lamps with a continuous current and noted the deflection of the instrument, then heated them up to the same degree of brightness as measured on the photometer, and noticed the deflection when they were lighted by an alternating current of 16,000 alternations per minute and could notice no difference in deflections.

The Chairman—The chair hears no further remarks, and we will, therefore, proceed to the next subject.

We are fortunate in having with us this evening a distinguished gentleman from abroad, a prominent mathematician, a well known contributor to that peerless European technical journal, *La Lumière Electrique*, and a gentleman who has an important official connection with the electrical department of the forthcoming Paris exhibition.

He will exhibit to us one of his own many inventions, an invention that I know will engage the earnest attention of a New York audience, because I may call it in the vernacular an apparatus for dispensing with cranks.

I have the pleasure of introducing to you Mr. Abdank-Abakanowicz, of Paris.

Mr. Abdank—Mr. Chairman and Gentlemen, before I begin I must crave an indulgence. I am only a beginner in knowledge of the English language, and my vocabulary has only a few words, and it is the first time that I have spoken in public in your language.

Mr. Abdank then read a paper on "The Abdank Magnetic Call and the Abdank Integraph." (See page 572.)

The Chairman—I think we will all agree that Mr. Abdank has given us a great deal of information in a very brief time. The subject is now open for discussion, and as we have with us a number of distinguished college professors, I would advise that these gentlemen be requested to open the discussion. Will Professor Geyer favor us with any remarks?

Professor Geyer—I would say that the chairman has made it difficult for any one to reply, for he has called the gentlemen distinguished, and it looks very egotistic to get up first.

The Chairman—The gentleman was called upon by name. He is relieved from the charge of immodesty in that respect.

Professor Geyer—I would just like to ask one question, in reference to one of the experiments the picture of which is on the middle blackboard, the current being an instantaneous current, whether it was attempted to make any corrections for the self-induction of the galvanometer coil. As I understand it, the current was just a momentary current.

Mr. Abdank—The current was relative to the period of oscillation of the needle.

Professor Geyer—What I meant was whether the current really had time to develop its strength as to its electromotive force.

Mr. Abdank—The difference would be small.

Professor Geyer—I was more particularly interested in the subject because I had somewhat analogous experiments made under my knowledge, where it was attempted to measure the current of the electromotive force of an alternating machine where the alternations took place at the rate of 16,000 a minute, and it was there done by causing a condenser to be discharged and then at pleasure discharge it also through a ballistic galvanometer.

Mr. Walcott—Having been for some time interested in the study of integrating machines of various kinds, and having invented some myself, I can say that I never have seen anything which will approach this instrument. The ordinary type of integrating machine which Mr. Abdank has spoken of will simply give a reading at the end of a given time—simply a single reading. We are all familiar, that is, all who have given any study to the subject at all with the apparatus of Professor James Thompson, Sir William Thompson's brother, which will integrate any expression involving a single variable. It is simply a disc and a sphere in a cylinder. The distance of the point of contact of the sphere from the centre of the disc will represent the variable quantity—that is the function, and if this distance can be

made to follow any required law of motion and that point of contact of the disc is transmitted to the circumference of the cylinder which is uniform the whole length, it is evident that the motion of the cylinder is proportional to the distance of the sphere from the centre of the disc. This apparatus will also—that is, a combination of several of them—will also integrate differential equations; but I never heard of any apparatus, I do not think there is any like this one we have seen to-night, which will trace out an integral curve, one curve, the ordinates in which are integrals of the ordinates in the other curve, and I would be very much obliged to Mr. Abdank if he could give us the principle of this machine. Has he any printed description of it?

Mr. Abdank—I am writing out a description of the apparatus for a paper, and perhaps that will answer the gentleman's purpose. It will be published shortly.

A Member—I would like to say in behalf of Mr. Abdank, that one of the features of that instrument besides tracing the integral curve, is that it can be used for solving numerical equations which, I understand, cannot be solved algebraically—equations of a high degree, 4th, 5th and 6th degree. The instrument will trace out a curve the dimension of which will give the values of equations of high degree—2d, 3d, 4th, 5th, 6th, and so on.

Mr. Walcott—Does that give all the real roots in one curve?

Mr. Abdank—Yes.

Professor Mayer—If the machine will do that it is a marvelous production of ingenuity and science. Charles Babbage, of England, gave his whole life to making a calculating engine. After he had perfected his difference engine and the British government would not supply him with means of bringing it out, he invented an analytical engine, of which you will find a description by the only daughter of Lord Byron, Lady Lovelace, which machine did just what this does. The construction of it would be so difficult that Babbage had not the means of bringing it out. If a machine so simple in its construction will do that, I can see that it is the most marvelous production of this age. I would like very much to understand it. Of course, I only see it there and I know nothing of the principle of it.

The Chairman—I understand, Mr. Abdank, to put it in plain language, for instance, in solving any equation of the second degree the instrument would describe a conic section and so on, the cessoids and higher curves according to the nature of the equation.

Mr. Abdank—Yes. (The speaker then put an equation on the black-board and further illustrated the operation of the integraph by example.) With respect to the calculating machine of Mr. Babbage—I know that machine very well. My instrument acts in a different way. The machine of Mr. Babbage is only an arithmetical machine. It has nothing to do with differentials.

After the foregoing discussion, Mr. Abdank exhibited the Melotrape and the Melograph of Mr. Carpentier, very ingenious contrivances for the automatic performance of music on the piano-forte, or similar keyed instruments, and for the automatic recording of improvisation on such instruments. At the request of Mr. Abdank, Mr. Carl Hering, of Philadelphia, explained the principles and mechanism of the machines, after which the Melotrape was operated by Mr. Abdank upon a piano-forte. A variety of selections were played, from the works of both classical and modern composers, to the great pleasure and interest of the audience.

Before adjournment, the thanks and congratulations of the Institute were voted to Mr. Abdank for his painstaking and instructive papers. The authorities of the College of the City of New York were also cordially thanked for their courteous hospitality.

WHAT SOME PEOPLE THINK OF THE ALTERNATING SYSTEM.

EDISON ELECTRIC LIGHT CO.
16 & 18 Broad Street,
New York, September 27, 1888.

To the HON. GEORGE F. EDMUNDS,
United States Senate, Washington, D. C.

Dear Sir:—I have been recently advised that the system of electric lighting now in use in the United States Senate Chamber is supplied by what is known as the "Alternating current," by which a very dangerously high pressure current is generated by the dynamo, distributed through the wires in the Senate Chamber, and reduced in pressure by the intervention of what is known as a "converter" before the current reaches the lamp. I am also credibly informed that considerable dampness exists on the walls of the Senate Chamber, and I am therefore impelled to call your attention to the existence of a very serious danger which threatens not only the destruction of the building by fire, but the life of persons coming in contact with the lamps, wires or other apparatus. The object of the "converter" above mentioned, is to reduce the dangerously high pressure before it enters the lamp; but the prevalence of moisture will cause condensation in the converter itself, the result of which will be that this high tension alternating current will be transferred directly to the lamp, in which case instantaneous death would be caused to any one handling the lamp or its attachments. I would farther call your attention to the fact that the only object in using this high tension current is to effect a small saving in the cost of the copper conductors in the first installment of the plant, while the cost of operating the plant is increased, thereby incurring an additional annual expense *in perpetuo*, by reason of the loss of current in the converters.

It is claimed by the adherents of the alternating system that their current is no more dangerous than the direct system; but recent exhaustive experiments have proven that while 1000 of pressure of the direct current may be taken with impunity, 200 units of pressure of the alternating system will cause instantaneous death. In support of this statement, I would particularly call your attention to the enclosed copy of a report of certain tests made by Mr. Harold P. Brown, a well-known Electrician of this city, in the Laboratory of Columbia College, under the auspices of Dr. Cyrus Edson, of our New York Board of Health, and other well-known authorities. I also enclose a copy of a letter addressed by the Hon. A. B. Cornell, of this city, to Mayor Hewitt, and a copy of a letter from Mr. Brown to Mr. Cornell, to all of which I would invite your careful attention, and which I am sure cannot fail to interest you.

I need not add that should you at any time desire any further or more specific information upon this subject, I shall be pleased to hear from you.

Yours very truly,
(Signed.) EDWD. H. JOHNSON,
President.

Endorsed as follows:—

"Respectfully forwarded to the Hon. Mr. Aldrich, Chairman of the Committee on Rules, with the suggestion that the matter would seem to be one worthy of early and close scrutiny.

Oct. 1, 1888. GEO. F. EDMUNDS.

GEO. C. MAYNARD,
Telegraphist and Electrician, No. 1409 New York Avenue.
Washington, D. C., Oct. 22, 1888.

EDWARD CLARK, ESQ.,
Architect U. S. Capitol, Washington, D. C.

Sir:—Acting upon your instructions, I have made a cursory examination of the Incandescent Electric Lighting apparatus in the Senate Wing of the Capitol Building, for the purpose of gaining information which would enable me to answer your question whether, in my opinion, "there is any danger attending the use of the apparatus."

This examination has led me to the conclusion that there is danger in such use.

The engineer in charge of the lighting plant very politely acceded to your request to explain its workings to me, and Mr. Jones, the Senate engineer, showed me over the routes of the wires, explained their construction, etc., etc. The former stated that each of the two dynamos, when running under normal conditions, develops a current of 1000 volts. I believe a current of such power is liable to cause the death of a person subjected to its effects.

The current from the dynamos is carried through a system of wires to a large number of converters located in various places in the basement of the building, and in the space over the ceiling of the Senate Chamber. These converters and much of the wire leading to them, are placed where there must necessarily be a great deal of work of various kinds done, and I think, that the risk that workmen employed in doing it may accidently and unknowingly make contact, directly or indirectly, with the apparatus and receive a dangerous current, is very great, and this risk, it appears to me, is liable to increase with lapse of time. A large number of other wires run in close proximity to the wires of the lighting system, some of them being stapled to the wooden casing covering the latter, and this complication, I think, renders it quite probable that the current may be directed from its proper channels into dangerous ways.

Your inquiry, did not, as I understand, relate to the question of danger from fire which might result from the use of the lightning system, but this is a matter which is also worth your attention.

Very respectfully,
Your obedient servant,
(Signed.) GEO. C. MAYNARD.

TREASURY DEPARTMENT, OFFICE OF THE SECRETARY.
Washington, D. C., October 22, 1888.

EDWARD CLARK, ESQ.,
Architect of the U. S. Capitol, Washington, D. C.

Sir:—Referring to the subject contained in the accompanying papers, submitted to you for my consideration and herewith respectfully returned, viz.—a communication from the president of the Edison Electric Light Co., of New York, and a report of tests made by Harold P. Brown, E. E., of that city, relative to the dangerous character of alternating currents, &c., the above having reference to the electric lighting system now in use in the Senate Wing of the Capitol. The system referred to is that known as the Westinghouse, alternating with a primary voltage of 1,000 volts reduced in "converters" and distributed at about 50 volts.

The transference of the high tension current to the distributing service through any accidental short circuiting in the "converters" or otherwise, would seriously imperil human life.

Regarding the deadliness of the alternating as compared with the "constant" current, the report of Mr. Brown, from his standing, and that of his associates, is deserving of fullest credence.

The danger to be apprehended in the use of the system referred to, is, however, extremely remote. The converters are not exposed to unusual dampness, and the system is carefully installed. The immunity from harm is a matter of insulation and thorough installation, by the contractors or owners, intelligence and carefulness on the part of those connected with the plant, and the absence of a disposition to meddle by those *not* connected therewith.

Given the above conditions and such a plant is as safe as any of the various forms of energy at high potential, but which it is absolutely impossible to remove from such risks as are inseparable from human management thereof.

Very respectfully,
(Signed.) J. E. POWELL,
Inspector Electric Light Plants, &c., Treasury Dept.

THE AMERICAN BELL TELEPHONE COMPANY ADJUDGED LIABLE TO TAXATION IN NEW YORK.

It was decided by the General Term of the Supreme Court, New York, November 23, that the American Bell Telephone Co. although a Massachusetts corporation, was liable to taxation on its business in this state. The state claims taxation on the earnings of the company and upon the amount of the capital stock employed in this state, with 10 per cent more for default in payment. Chief-justice Van Brunt and Justice Daniels hold that the company is liable to taxation, and judgment was given for $34,478.90.

In his opinion, Judge Van Brunt holds that the company is not liable prior to 1885, when the law was amended making these corporations liable only for a portion of the capital stock employed in this state, and not the whole of the companys' capital stock. Judge Daniels says that the property of the company, even when it passes into the hands of other companies for use for any period of time, never passes from the control of the owners, who enjoy the protection of the state. The company is, therefore, clearly liable to taxation. Judge Brady coincides with Judge Daniels.

ACCUMULATORS MEET AN EMERGENCY.

Owing to an accident to the steam plant in the residence of J. Pierrpont Morgan, 36th street and Madison avenue, New York city, several weeks ago, he was left without any means of illumination except candles, gas having been abolished some time previously, and as he expected to give a large dinner party the following evening it was necessary to take prompt measures to remedy the defect. The Electrical Accumulator Company having a supply of accumulators for temporary lighting, began the work of charging them at 4 o'clock in the afternoon, finishing at 12 o'clock noon the next day. The accumulators (60 "15A" type) were then placed in crates, loaded on trucks and carted from their Newark factory to Mr. Morgan's house (10 miles), set up with necessary switches and appliances and at 6 o'clock the light was turned on, thus supplying Mr. Morgan with electric light in ample time for his entertainment. He has expressed himself has greatly pleased with the success of the experiment, and has now arranged for a permanent installation of accumulators as an adjunct to the Edison direct lighting plant, thus supplying him with means of illumination during such periods of time as the direct service from any cause may not be available, and also on special occasions, such as entertainments, etc., when all, or nearly all, of the lamps in the house may be required, and which latter contingency could not otherwise be provided for except by the use of a larger dynamo.

THE TELEPHONE.

THE LOWTH STETHO-TELEPHONE Co., of Chicago, claims that its telephones escape the fundamental claim of the Bell patent. The Lowth telephone is said to employ the actual vibrations of the vocal organs to actuate its mechanism, through the impact of a button placed against the throat in the vicinity of the larynx, and is therefore said to be independent of the air vibrations used to actuate the diaphragm of the Bell telephone. It is doubtless superfluous to direct the attention of the inventor and promoters to the effect of the presence of the casual blue-bottle fly upon stethoscopic apparatus, illustrated in Dr. Oliver Wendell Holmes' touching verses on the subject.

ELECTRIC LIGHT AND POWER.

FORT WAYNE, IND.—A despatch to the *Evening Telegram*, November 23, reports the destruction by fire of the extensive works of the Fort Wayne Jenney Electric Light Co. The entire plant, including the old and new buildings and the plant of the Star Iron Tower Co., were entirely destroyed. The loss on buildings, stock and machinery is given at $300,000 upon which there is an insurance of $148,000. The origin of the fire is supposed to have been spontaneous combustion.

THE HEISLER ELECTRIC LIGHT CO.'S LIST OF CENTRAL STATIONS USING THE HEISLER INCANDESCENT LONG-DISTANCE SYSTEM, ERECTED OR CONTRACTED FOR TO NOVEMBER 17TH, 1888.

The generating capacity is based on 30 candle lamps as a standard. Lamps in actual service vary from 10 up to 100 candle.

Location.	No. of 30 c.p. lamps	Operating Company.
Albany, Ore	160	Albany Electric Light Co
Baltimore, Md	2,400	Baltimore Illuminating Co
Buena Vista, Col	300	Buena Vista Electric Light Co
Buenos Ayres, South America.	500	Rufino, Varela Hijo & Cia.
East Portland, Ore	160	H. A. Hogue Electric Light Central Sta.
El Paso, Texas	300	El Paso Gas and Electric Light Co
Eugene City, Ore	460	Eugene Electric Light Co
Fayetteville, Ark	300	Fayetteville Electric Light & Power Co.
Fergus Falls, Minn	400	Fergus Falls Gas & Electric Light Co
Grand Junction, Col	300	Grand Junction Tel. & Electric Light Co.
Greenport, N. Y	200	Greenport Electric Light & Power Co
Hackettstown, N. J	160	Hackettstown Electric Light Co
Kingman, Kas	160	Kingman Electric Light Co
Kingston, Pa	225	Kingston Electric Light Co
Leavenworth, Kas	800	Leavenworth Coal Co
Liberty, Mo	160	Liberty Electric Light Co
Mankato, Minn	160	F. L. Watters, Electric Light Central Sta.
Marion, Ohio	300	Marion Electric Light & Power Co
Matteawan, N. Y.	750	Cassoll Electric Light Works
Merced, Cal	165	Merced Gas Co
Meriden, Conn	300	Meriden Electric Light Co
Michigan City, Ind	300	Rawson, Root & Co., Elec. Light Cen. Sta.
Monticello, Minn	160	Monticello Electric Light Co
Napa, Cal	160	Napa & Sonoma Electric Light Co
Oakland, Me	160	Oakland Electric Light Co
Ocean Grove, N. J	460	Ocean Grove Camp Meeting Association.
Ogden, Utah	400	Ogden City Electric Light Co
Orange, N. J	310	R. B. Suckley, Electric Light Central Sta.
Ottawa, Kas	160	Ottawa Electric Light Co
Pendleton, Ore	160	Pendleton Electric Light Co
Pueblo, Col	700	Pueblo Gas & Electric Light Co
Red Bank, N. J	340	Red Bank Electric Light Co
Salem, Ore	300	Thos. Holman, Elec. Light Central Station
Salt Lake City, Utah	340	Salt Lake City Gas & Electric Light Co
Saugerties, N. Y	230	J. J. Sheffield & Son, Elec. Light Cen. Sta.
Sault Ste. Marie, Ontario, Can.	500	Sault Ste. Marie Water, Light & Heat Co.
St. Louis, Mo	2,400	St. Louis Illuminating Co
Vincennes, Ind	340	Vincennes Electric Light & Power Co.
Wabash, Ind	160	Wabash Electric Light Co
Yonkers, N. Y	225	Yonkers, Schuyler Electric Light Co
	16,465	

THE HILL CLUTCH WORKS, Cleveland, O., will furnish the entire power plant for the electric lighting station of the New Bedford Gas Co., New Bedford, Mass. They designed the plant, making complete drawings of everything, and have secured the contract for the work.

THE WESTINGHOUSE ELECTRIC CO. enters the field of arc lighting through its acquisition of the entire capital stock of the Waterhouse Electric and Manufacturing Co. The machinery for the manufacture of the arc apparatus of that company is being erected in the works of the Westinghouse company at Pittsburgh, and preparations are being made to conduct the manufacturing on an extensive scale.

THE WATERHOUSE COMPANY has about 5,000 arc lights in operation and a number of important stations.

THE THOMSON-HOUSTON ELECTRIC CO. reports the following new business :—

	Arc lamps.	Incandescent lamps.
Chattanooga, Tenn	200	
Findley, Ohio	185	
Wood, Brown & Co., Philadelphia, Pa	60	
Young, Smith & Co., Philadelphia, Pa	60	
Ensley, Ala	35	

And the following increases :—

	Arc lamps.	Incandescent lamps.
Johnstown, N. Y	50	
Salem, Mass	25	
Columbus, Ohio	100	
Worcester, Mass	35	
Portland, Maine	35	800
East River Company, New York City	100	1,000
Toledo, Ohio	100	
Mobile, Ala	85	
Nashua, N. H	45	
Oneida, N. Y	35	
Waltham, Mass	50	
Cambridge, Mass	45	
Columbia, S. C	30	
Atlanta, Ga	50	
Hyde Park, Mass	50	
Buffalo, N. Y		800
Stamford, Conn	30	
Rome, N. Y	50	
Somerville, Mass	50	
Waterville, Conn		500
Malden, Mass		500

A SUCCESSFUL test was made November 24, at Virginia, Nevada, of a 60-stamp quartz mill, which was run by Brush motors, the current being obtained from dynamos located in the Sutro tunnel, 1,700 feet below the surface; these dynamos being driven by six large Pelton water wheels with a pressure of 680 pounds to the square inch. This water power does not equal, however, that of the Truckee river, 16 miles distant from the Comstock mines, and it is probable that before long, hundreds of stamp mills will be in operation by electric motors, which have proven the only kind of power sufficiently economical to permit of the working of low grade ores at a profit. It is said that over $40,000,000 has been spent in a fruitless endeavor to secure the above result.

Foreign.

Australia.—THE ELECTRIC LIGHT PLANT AT THE INTERNATIONAL EXHIBITION.—The Centennial International Exhibition, which was held in commemoration of the centenary of British settlement in Australia, was formally opened upon August the first, last.

The exhibition covers 35½ acres of space, throughout which are distributed 1,000 arc lights of the Brush system, and 2,000 16-c. p. Swan incandescent lamps. The entire electrical installation was done by the Australian Electric Light, Power and Storage Co., and is claimed to be the largest installation of its kind.

Six engines of 200 h. p. each are employed to drive a line of shafting 160 feet in length, with which the dynamos—49 in number—are connected.

Germany.—ELECTRIC LIGHTING.—The work done by the Edison company in Berlin, is said to be so good that the public and the municipal authorities have perfect confidence in their ability to extend their central station work still further, and a concession has been given to the company for the establishment of two new stations—one in the centre of the town and the other in the south-east quarter, where most of the engineering works and other factories are situated. Both stations must be ready within two years, and each must be able to supply current for 6,000 lamps burning simultaneously. The station in the centre of the town will eventually be increased to a capacity of 24,000 lamps, and the other station will be increased to 12,000 lamps, the annual increase to be not less than 6,000 and 3,000 lamps respectively. All the cables required in connection with these stations must be in position by the end of 1892, and the supply of current within both districts will be compulsory, provided the customer is willing to take the light for at least one year. The network of cables to be laid down in connection with these stations is very complete, and practically comprises all the streets of the respective districts, some small and unimportant side streets alone excepted. In view of this extension of their business, the Edison company propose to increase their share capital at present by $750,000, and later on by $1,500,000. The electric light installation in the Monopol Hotel of

Berlin, which comprises 1,000 lamps, will shortly be in action. The work has been executed by the Berliner Maschinenbau-Actien-gesellschaft, under the superintendence of Herr Beringer. The current is supplied by two 80 h. p. dynamos, each direct coupled to a twin engine. The dynamos are of the eight pole disc type, and are compound-wound. Steam is supplied by two Babcock & Wilcox boilers, having collectively a heating surface of 2,400 square feet.

MANUFACTURING AND TRADE NOTES.

MESSRS. JAS. W. QUEEN & Co., Philadelphia, so long and widely known as makers and importers of physical and chemical apparatus, are making the electrical department of their business a prominent feature. Their electrical testing apparatus covers a large variety of instruments, of both old and new types; as was very obvious to all who examined their extensive exhibit at the electric light convention in August.

THE HAWKEYE ELECTRIC Co. has been re-organized, and will be removed from Oskaloosa, Iowa, to Davenport, Iowa, in order to take advantage of the better facilities for manufacturing and shipping which the latter city affords. Mr. William Bowen will continue as general manager, and Mr. Frank Thone, as electrician.

MR. A. A. MCCREARY, of 15 Cortlandt street, has placed upon the market a novel reflector for incandescent lights. It is simple in design. A combination of ground glass and silver leaf is used to secure an equal diffusion of light, entirely eliminating the glaring effect of the naked lamp.

MR. W. R. RATHVON, of Denver, Col., announces that he is about to open an electrical supply house in that city.

THE HARRISBURG CAR MANUFACTURING Co., foundry and machine department, report large sales of engines, boilers and machinery during the present season. The Ide engine made by them finds much favor for electric light stations. Among 20 engines ordered during October and to November 9, are two 150 h. p., Reading, Pa., Electric Light Co.; one 30 h. p., Middletown Delaware Electric Co., and one 100 h. p., Augusta, Ga., National Exposition.

MESSRS. C. E. JONES & BROTHERS, Cincinnati, send us a pamphlet describing a small dynamo of 18-light capacity, made by them for use wherever a small isolated plant is desirable. The machine is very fully described and illustrated in detail, with particulars of dimensions, etc. The pamphlet will prove interesting to young students and experimenters, as well as to many people who want electric lighting outfits on a small scale. There is obviously a very considerable field for the use of outfits of from 10 to 20 lamps—in stores, offices, small workshops, even residences, where a suitable supply of power is available.

THE UNION SWITCH AND SIGNAL Co. has arranged for the exclusive right to manufacture and sell a new form of car buffer invented by Mr. George Westinghouse, Jr., which it is claimed will meet a want heretofore unfilled; namely, a device offering resistance to the inward movement of the draw-bar sufficient to absorb in itself the momentum of the load in ordinary working in such a way that the shock and consequent injury to the car, heretofore considered unavoidable, will be obviated.

The device consists of a cast-iron box containing a number of thin plates secured to it, and a like number of thin plates placed between those in the box and attached to movable pieces against which the draw-bar presses. When the draw-bar is pressed inwardly these thin plates are, by a simple wedge device, clamped or squeezed together so as to offer an immense frictional resistance to further inward movement, which together with the resistance of the main springs (the same as heretofore used), absorbs such an amount of momentum that it is possible to run one car into another at a speed of 8 or 10 miles an hour without fully exhausting the frictional resistance and compression of the springs.

Not only do the friction plates of the buffer offer an immense resistance, but the reaction of the main springs is prevented, thus assisting materially to decrease the risk of breaking trains in two. The apparatus is simple in construction, and is applicable to any form of draw-bar, but will be particularly valuable in connection with the Janney type of coupling, which does not at all times admit of the action of the dead blocks.

The apparatus has been designed with reference to securing uniformity in draw-gear, and is applicable to all classes of cars, freight and passenger, and its peculiar construction admits of a new method of attaching draw-gear, which will give all the practical effect of a continuous draw-bar, if desired; and the saving effected in attaching the apparatus is nearly equal to the cost of the special casting and frictional parts.

THE JULIEN ELECTRIC Co. report largely increased sales of their storage battery. From November 1st to the 16th, eleven (11) installations have been sold, amounting in all to 1,540 accumulators—thought to be the largest sales probably ever made here or abroad in the same length of time by any company engaged in storage battery business.

ELECTRIC STREET RAILWAYS IN AMERICA.

Now in Operation.

ABBREVIATIONS.—mi., miles of single track; g., gauge; lb., pounds rail per yard; m., electric motors; c., cars; m. c., motor-cars; h. p., horse-power; T., T-rail. Name of electric system used is in SMALL CAPITALS.

Akron, Ohio.—Akron Electric Ry. Co. 6½ mi.; 12 m. c.; overhead cond. SPRAGUE.

Allegheny, Pa.—Observatory Hill Pass. Ry. Co.—*Pr.*, Oliver P. Scaife; *Sec.*: Arthur Kennedy; *Tr.*, Jas. B. Scott; *Supt.*, Alexander Moffat; *Eng.*, —— 3-7 mi.; g. 5-2½; 52 lb.; 4 m. c.; sta., 200 h. p.; overhead and conduit cond. BENTLEY-KNIGHT.

Ansonia, Conn.—Derby Horse Ry. Co.—*Pr.*, Jno. B. Wallace; *Sec.* and *Treas.*, Wm. J. Clark; *Supt.* Jas. D. Kennedy; 4 mi.; g. 4-8½: 45 lb.; 3 m. c.; 1 m.; sta. —— h. p.; overhead cond. THOMSON-HOUSTON.

Appleton, Wis.—Ap. Electric St. Ry. Co.—*Pr.*, J. E. Harriman; *Sec.*, F. W. Harriman; *Tr.*, F. W. Harriman; *G. M.*, A. A. Jöhnson; *Eng.*, N. M. Edwards; 5.5 mi.; g., 4-8½; 35 lbs.; 6 m. c.; sta., 60 h. p.; water power; overhead cond. THOMSON-HOUSTON.

Asbury Park, N. J.—Seashore Elect. Ry. Co. (41 Wall St., N. Y.) *Pr.*, F. W. Childs; *Se.*, W. P. Stevenson; *Supt.*, G. L. Jeralomon; 4 mi.; g. 4-8½; 47 lbs.; 12 m. c.; sta. 100 h. p.; overhead cond. DAFT.

Baltimore, Md.—Balt. Union Pass. Ry. Co.—*Pr.*, N. Perrin; *G. M.*, T. C. Robbins; *Sec.*, Leon Fender; 2 mi.: g., 5-4½; 47 lb.; 4 m. c.; sta. —— h. p.; overhead cond. DAFT.

Binghamton, N. Y.—Washington St., Asylum & Park R. R.—*Lessee*, S. M. Nash; *Supt.*, H. P. Wilcox; *Eng.*, E. P. Morris; 4.5 mi.; g. 4; 35 lb., 8 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Birmingham, Ct.—Derby Horse Railway Co.—*Pr.*, H. H. Wood; *Sec.*, Wm. J. Clark; *Treas.*, Chas. E. Clarke; 4 mi.; 94′ 8½″; m 5; c. 4; h. p. 100. VAN DEPOELE.

Brockton, Mass.—East Side St. Ry. Co.—*Pr.*, A. F. Small; *Clerk*, C. A. Noyes; *Tr.*, C. D. Fullerton; *Eng.*, E. L. Brown; 4½ mi.; g. 4-8½; 40 lb.; 4 m. c.; steam-power sta. 60 h. p.; overhead cond; 4 m. c. SPRAGUE.

Carbondale, Pa.—Carbondale & Jermyn St. Ry.—*Pr.*, John W. Aitken, *Sec.* and *Treas.*, J. E. Burr; *G. M.*, John Aldrich; 5 mi.; g. 4-8½; 30 and 60 lb.; 3 m. c.; 1 m.; steam power; sta. 75 h. p.; overhead cond. SPRAGUE.

Cincinnati, O.—Mt. Adams and Eden Park Inclined Ry. Co.—*Pr.*, Geo. B. Kerper; *Sec.*, J. R. Murdock; *Tr.* and *G. M.*, G. B. Kerper; *Supt.*, R. Palley; *Eng.*, H. Kolf; 1 mi.; g. 5-2½; 52 lb.; 3 m. c.; 3 m. overhead cond.

Columbus, O.—Columbus Consolidated Street Ry. Co.—*Pr.*, A. D. Rodgers; 2 mi.; g. 5-2; 2 m. c.; 30 lbs.; 2 c.; sta., 250 h. p.; underground conduit. SHORT.

Crescent Beach, Mass.—Lynn & Boston St. Ry. Co.—1 mi.; 1 m. c.; overhead. THOMSON-HOUSTON.

Davenport, Iowa.—Davenport Central St. Ry.—*Pr.*, W. M. Grant; *Sec.*, G. S. McNeil; *Tr.*, J. B. Fidlar; *Supt.*, J. W. Howard; 3½ mi.; 8 m. c.; overhead cond. SPRAGUE.

Dayton, O.—White Line St. R. R. Co.—*Pr.* John A. McMahon; *Sec.* Chas. D. Iddings; *Treas.* Michael A. Nipgen; 8.5 mi.; g. 4-8½; 38 lb.; 16 c.; 12 m. c.; sta. 240 h. p.; overhead and conduit cond. THOMSON HOUSTON.

Detroit, Mich.—Detroit Elect. Ry. Co.—*Pr.*, N. M. Campbell; *Sec.*, B. Duffield; 4 mi.; g.——; 30 lb. T; 4 m. c.; sta. —— h. p.; overhead cond. THOMSON-HOUSTON,

Highland Park Ry. Co.—*Pr.*, Frank E. Snow; *Sec.*, Fremont Woodruff; 3.5 mi.; g. 4-8½; 25 and 35 lbs.; 2 c.; 4 m. c.; sta. 60 h. p.; conduit cond. FISHER.

Easton, Pa.—Lafayette Traction Co.—*Pr.* J. Marshall Young; *Sec.* and *Treas.*, D. W. Nevin; *Supt.*, Mr. Richardson; 1 mi.; g. 5-2; 35 lb.; 2 m. c.; sta. 40 h. p.; overhead cond. DAFT.

Fort Gratiot, Mich.—Gratiot Elect. Ry.—Officials same as Port Huron Elect. Ry.; 1.75 mi.; g. ——; 16 lb. T; 1; 2 m. c.; ——h. p.; conduit. THOMSON-HOUSTON.

Harrisburg, Pa.—East Harrisburg Pass. Ry. Co.—*Pr.*, W. J. Calder; *Sec.*, D. Fleming; *Tr.*, T. D. Greenawalt; *Supt.*, J. Schaffner; 4.5 mi.; g. 5.2½; 52 lbs.; sta. 160 h. p.; 10 m. c.; overhead cond. SPRAGUE.

Hartford, Conn.—Hartford & Weathersfield Horse R. R. Co.—*Pr.*, E. S. Goodrich; *Sec.*, D. R. Howe; 12 mi.; g. 4-8½; 45 lb.; 2 m. c.; overhead cond. SPRAGUE

Ithaca, N. Y.—Ithaca St. Ry. Co.—*Pr.*, D. W. Burdick; *Sec.*, J. Murray Mitchell; *Tr.* T. F. Van Fleet; 1 mi.; g. 4-8½; 30 lb. T.; 2 m. c.; sta. 20 h. p.; overhead cond. DAFT.

Jamaica, N. Y.—Jam. & Brooklyn R. R. Co.—*Pr.*, Aaron A. Degrauw; *Sec.*, Martin J. Duryea; *Supt.*, Wm. M. Scott; 10 mi.; g. 4-8½; 56 and 60 lb.; 10 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Lafayette, Ind.—Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2.25 mi.; g. 4-8½; 52 lb.; 8 m. c.; overhead cond. SPRAGUE.

Lafayette St. Ry.—*Pr.*, G. E. C. Johnson; *Sec.*, T. J. Levering; 2¼ m.; g. 4 8½; 27-35-52 lb.; 9 m c.; 9 Sprague cars. SPRAGUE.

Lima, O.—The Lima St. Ry. Motor & Power Co.—*Pr.*, B. C. Faurot; *Sec.*, F. L. Langan; *Supt.*, J. H. Rose; 6 mi.; g. 4-8½; 40 lb.; T; 7 m. c.; sta. 100 h. p.; overhead cond. THOMSON-HOUSTON.

Los Angelos, Cal.—Los Angelos Elect. Ry. Co.—*Pr.*, G. H. Bonebrake; *Sec.*, and *G. M.*, C. H. Howland; 5 mi.; g. 4-8½; —— lb.; 4 m. c.; sta. ——h. p.; overhead cond. DAFT.

Lynn, Mass.—Lynn & Boston Ry. Co.—*Pr.*, A. F. Breed; *Tr.* and *Clerk*, E. F. Oliver; *Supt.*, L. C. Foster; g. 4-8½; 2 m. c.; overhead cond. THOMSON-HOUSTON.

Mansfield, O.—Mansfield Elec. St. Ry. Co.—*Pr.*, Edw. Oathout (New York); *Sec.*, C. E. McBride; *Supt.*, W. G. Root; *Eng.*, Knight Neftel; 4.5 mi.; g. 4-8½; 43 lb.; 5 m. c.; sta. —— h. p.; overhead cond. DAFT.

Meriden, Conn.—New Horse R. R.—*Pr.*, T. J. Lathram; *Sec.* and *Tr.*, T. A. Lamb; 5 mi.; g. 4-8½; 35 lb.; 12 m. c.; overhead cond. DAFT.

Meriden, Conn.—Meriden Horse R. R. Co.—*Pr.*, Geo. R. Curtis; *Sec.* and *Tr.*, C. L. Rockwell; *Supt.*, D. Barker; 5 mi.; g. 4-8; 35 lb.; 12 m. c. DAFT.

Montgomery, Ala.—Capital City Elec. St. Ry. Co.—*Pr.* E. B. Joseph; *Supt.* G. B. Shellhorn; *Sec.*, W. F. Joseph; 7-9 mi.; g. 4; 42 lb.; 14 m. c.; sta. 150 h. p.; overhead cond. THOMSON-HOUSTON.

Omaha, Neb.—Omaha and Council Bluffs Ry. & Bridge Co.—*Pr.*, Dr. S. D. Mercer; *Sec.*, J. T. Hertzman; *Treas.*, S. S. Curtis; 9 mi.; g. 4-8½; 56 lb.; 12 m. c.; sta. 250 h. p.; overhead cond. THOMSON-HOUSTON.

Pittsburgh, Pa.—Pitts., Knoxville & St. Clair St. Ry.—*Pr.*, Theo. Evans; *Tr.*, Henry Stamm; *Sec.*, J. W. Patterson; 2½ mi.; g. 5-2½; 43 lb.; 5 c.; 5 m.; steam-power; sta. 200 h. p.; overhead and conduit cond. DAFT.

Port Huron, Mich.—Port Huron Elect. Ry.—*Pr.*, Wm. P. Botsford; *Sec.* and *Supt.*, Jas. H. Talbot; 4 mi.; g. 4-8½; 27 lb.; 6 m. c.; sta. 55 h. p.; overhead cond. THOMSON-HOUSTON.

Revere, Mass.—Revere Beach Ry. Co.—1 mi.; 1 m. c.; overhead. THOMSON-HOUSTON.

Richmond, Va.—The Richmond Union Pass. Ry. Co.—*Pr.*, W. R. Trigg; *Sec.* and *Tr.*, Andred Pizzini; *G. M.*; G. A. Burt; *Eng.* A. L. Johnston; 13 mi.; g. 4-8½; 45 lb.; 40 m. c.; sta. 400 h. p.; overhead cond. SPRAGUE.

Salem, Mass.—Naumkeag St. Ry. Co.—*Pr.*, C. Odell; *Tr.*, H. Wheatland; *Sec.*, J. F. Hickey; *Supt.*, W. B. Furgurson; 1½ mi. Willows branch; g. 4-8½; 6 m. c.; 35 lb.; 80 p. c.; sta. 100 h. p.; 6 m. c.; overhead cond. SPRAGUE.

San Diego, Cal.—San Diego St. Ry. Co.—*Pr.*, Dr. Granchenor; *V. P.*, Juan Francesco; 9 mi.; 4 m. c.; overhead cond. HENRY.

San Jose, Cal.—San Jose & Santa Clara R. R. Co.—*Pr.*, S. A. Bishop; *Sec.*, E. Rosenthall; *Tr.*, J. Rich; *Supt.*, W. Fitts; 10 mi.; g. 3; 6 m. c.; sta. 130 h. p; conduit cond. FISCHER.

St. Catherines, Ont.—St. Catherine's, Merritton & Thorold St. Ry. Co.—*Pr.*, E. A. Smyth; *Sec.*, A. P. Friesman; *Supt.*, R. McMaugh; *Eng.*, W. S. Smith; 5.75 mi.; g. 4-8½; 30 lb.; 4c.; 10 m. c.; sta. 400 h. p. (water power); overhead cond. VAN DEPOELE.

St. Joseph, Mo.—St. Joseph Union Pass. Ry. Co.—*Pr.*, Seymour Jenkins; *Sec.* and *Tr.*, A. Steinacker; *Supt.*, Chas. Wilson; 9½ mi.; g. 4-8½; 35 lb.; 8 m. c.; 13 m. c.; overhead cond. SPRAGUE.

Scranton, Pa.—Scr. Suburban Ry. Co.—*Pr.*, Edw. B. Sturges; *Sec.*, G. Sanderson; *Tr.*, T. F. Torrey; *Supt.* and *G. M.*, B. T. Killam; *Eng.*, J. Nazel; 4.5 mi.; g. 4-8½; 35, 40 and 52 lb.; 10 m. c.; sta. 300 h. p.; overhead cond. THOMSON-HOUSTON.

Nayang Cross-Town Ry.—3 mi.; 4 m. c.; overhead. THOMSON-HOUSTON.

Scranton Pass. Ry.—2 mi.; 4 m. c.; overhead. THOMSON-HOUSTON.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, W. B. Cogswell; *Sec.* and *Tr.*, W. S. Wales; 4 mi.; g. 4-8½; 35-50 lb.; 8 m. c.; overhead cond. THOMSON-HOUSTON.

Washington, D. C.—Eckington & Soldier's Home Ry. Co.—2.14 mi.; 3 m. c.; overhead cond. THOMSON-HOUSTON.

Wheeling, W. Va.—Wheeling Ry. Co.—*Pr.*, Jno. Spiedel; *Sec.*, Jno. M. Sweeney; 5.25 mi.; g. 5-2; 45 lb.; 10 m. c.; sta. 240 h. p.; overhead cond. THOMSON-HOUSTON.

Wichita, Kas.—Riverside & Suburban Ry. Co.—*Pr.*, G. C. Strong; *Supt.*, O. J. Chapman; (contract for 2 miles); 7 mi.; 30-40 lb.; 3 m. c.; overhead cond. THOMSON-HOUSTON.

Wilkesbarre, Pa.—Wilkesbarre & Suburban St. Ry. Co.—*Pr.*, H. H. Sen; *Sec.*, W. E. Shupp; *Tr.*, C. Walter; *Supt.*, A. C. Robertson; 3-6 mi.; g. 5-2; 50 lb.; 7 m. c.; sta. 120 h. p.; overhead cond. SPRAGUE.

Wilmington, Del.—Wilmington City Ry. Co.—*Pr.*, W. Canby; *Sec.* and *Tr.*, J. F. Miller; *Supt.*, W. H. Burnett; 6½ mi.; g, 5-2; 47 lb.; 13 m. c.; overhead cond. SPRAGUE.

Windsor, Ont.—Windsor Elect. St. Ry. Co.—*Pr.*, W. M. Boomer; *Sec.*, A. H. Joseph; *Supt.* W. C. Turner; *G. M.*, P. C. Ponting; 1.5 mi.; g. 3-6; 25 lb.; 1 c.; 2 m. c.; sta. 20 h. p.; overhead cond. VAN DEPOELE.

Woonsocket, R. I.—Woonsocket, St. Ry. Co.—*Pr.*, Horace H. Jenckes; *Sec.* and *Eng.*, Willard Kent; 1 mi.; g. 4-8½; 25 and 50 lb T; 1 m. c.; sta. 1,000 h. p.; overhead cond. THOMSON-HOUSTON.

Constructing or Under Contract.

Alliance, O.— 2 mi.; 3 m. c.; overhead. THOMSON-HOUSTON.

Asheville, N. C.—Asheville St. Ry.—3 miles; 4 m. c.; overhead cond. SPRAGUE.

Attleboro, Mass.—Att., N. Attleboro & Wrentham St. Ry. Co.—*Pr.*, H. G. Bacon; *Tr.*, J. E. Draper; *G. M.*, H. M. Daggert, Jr.; 6 mi.; g. —— lb.; —— c.; —— m.; sta. —— h. p.; overhead cond.

Bangor, Me.—Bangor St. Ry. Co.—5 mi.; 4 m. c.; overhead. THOMSON-HOUSTON.

Boston, Mass.—West End Ry. Co., Brookline branch.—12 mi.; 20 m. c.; overhead cond. SPRAGUE.

West End Ry. Co., Harvard Square Branch.—14 mi.; 20 m. c.; overhead. THOMSON-HOUSTON.

Buffalo, N. Y.—Citizen's Elect. Ry. Co.—*Pr.*, A. P. Wright; *Sec.*, F. F. Fargo.

Chattanooga, Tenn.—Chat. Elect. St. Ry. Co.—*Pr.*, C. A. Lyerly; *Sec.*, C. E. Scott; *Tr.*, C. V. Brown; *G. M.*, E. Scott; 4 mi.; g. 4-8½; 25 lb.

Cleveland, O.—East Cleveland R. R. Co.—*Pr.*, A. Everett; *Sec.* and *Tr.*, H. A. Everett; *Supt.*, E. Duty; 23½ mi.; g. 4-8½; 45 lb.; 16 m. c.; overhead cond. SPRAGUE.

Brooklyn St. Ry. Co.—10 mi.; 10 m. c.; overhead. THOMSON-HOUSTON.

Danville, Va.—Danville St. C. Co.—*Pr.*, F. B. Fitzgerald; *Sec.* and *Tr.*, P. R. Jones; *Supt.*, M. W. Buckley; 1.6 mi.; g. 4-8½; 38 lb.; 2 m.c.; overhead cond. THOMSON-HOUSTON.

Des Moines, Iowa.—Capital City St. Ry. Co.—*Pr.*, G. Van Ginkel; *Sec.*, H. E. Teachout; *Tr.*, J. Weber; 7 mi.; g. 4-8½; 45 lb.; 8 m. c.; overhead cond. THOMSON-HOUSTON.

Elsinore, Cal.—Elsinore Lake Shore Elect Ry. Co.—*Pr*, D. G. Dexter; *Sec.* and *Manager*, H. L. Courad; *Tr.*, F. H. Heald.

Erie, Pa.—Erie City Pass. R. R. Co.—*Pr.*, W. W. Reed; *Sec.*, J. L. Sternberg; *Supt.*, Jacob Borst.; 8½ mi.; g. 4-8½; 20 m. c.; overhead cond. SPRAGUE.

Flushing, N. Y.—Flushing & College Point St. R. R.—*Pr.*, J. Dykes; *Sec.*, Charles Frey; *Tr.*, Henry Clement; g. 4-8½; 45 lb.; 1 mi.; storage bats.

Hudson, N. Y.—Hudson St. Ry. Co.—*Pr.*, H. McGonigle; *Sec.*, E. J. Hodge; *Tr.*, S. D. Loke; 2.5 mi.; g. 4-8½; 30-50 lb.; 3 m. c.; overhead cond. THOMSON-HOUSTON.

Lakeside, O.—3 mi.; 2 c.; overhead cond.

Lincoln, Neb.—Lincoln Cable Ry. Co.—*Pr.*, J. H. Ames; *Sec.*, L. Coon; 5 mi.; g. 4-8½; 56 lb.; 10 m. c.; storage bats.

Louisville, Ky.—Central Pass. R. R. Co.—*Pr.*, B. du Pont; *Sec.*, J. C. Donigan; —— mi: g. 5; 10 m. c. THOMSON-HOUSTON.

Manchester, Va.—Richmond & Manchester Ry. Co.—*Pr.*, J. E. Taylor; *V. Pres.*, J. Bryan; *Sec.* and *Treas.*, Jackson Brandt; *Supt.* B. R. Selden; 3¾ mi.; g. 4-8¼; 38 lb.; 10 m. c., 10 Sprague cars; overhead cond. SPRAGUE.

Minneapolis, Minn.—Minneapolis St. Ry. Co.—*Pr.*, Thos. Lowry; *Sec.* and *G. M.*, J. E. Rugg; *Treas.*, M. B. Koon; *Supt.*, D. W. Sharp; *Eng.*, E. T. Abbott; 69¼ mi.; g. 3-6; 27-35-45 lb.; 8 m. c.; overhead cond. SPRAGUE.

Newton, Mass.—Newton St. Ry. Co.—*Pr.*, H. B. Parker; *V. P.*, Joseph W. Stover; *Sec.* and *Treas.*, H. C. Pratt (office, Newtonville, Mass); 6 mi.; g, 4-8½; 52 lb.

New York, N. Y.—N. Y. & Harlem (Fourth Avenue) R. R. Co.—*Pr.*, C. Vanderbilt; *Sec.* and *Treas.*, E. V. W. Rossiter; *Supt.*, Alfred Skitt; 18½ mi.; g. 4-8½; 60 and 75 lb.; 10 m. c.; storage bats. JULIEN.

New York, N. Y.—North & East River Ry. Co.—*Pr.*, W. W. Laman; 1 mi.; g. 4-8½; cond. conductor. BENTLEY-KNIGHT.

North Adams, Mass.—Hoosac Valley St. Ry.—*Pr.*, W. B. Baldwin; *Sec.*, S. P. Thayer; *M.*, H. A. Fitzsimons; 5 mi.; g. 4-8½; 40 lb.; 6 m. c.; overhead cond. THOMSON-HOUSTON.

Ontario, Cal.—Ontario & San Antonio Heights Ry. Co.—*Pr.*, Chas. Frankish; *Sec.* and *Treas.*, D. McFarland; 8 mi.; g. 4-8½; 34 lb.; 4 c.; 3 m.; overhead cond. DAFT.

Ottawa, Ill.— 6 mi.; 8 m. c.; overhead. THOMSON-HOUSTON.

Philadelphia, Pa.—Lehigh Ave. Ry. Co.—*Pr.*, J. T. Banting; *Sec.* and *Treas.* J. McK. Barron; 6 mi.; g. 5-2½; 47 lb.; storage.

Port Chester, N. Y.—P. C. & Rye Beach St. Ry. Co.—*Pr.*, F. H. Skeele; *Sec.*, E. H. Cook; *Tr.*, C. D. Newton; *V. P.*, M. Dillon; *Supt.*, T. M. Burt; 3 mi.; g. 4-8½; 38 lb.; 5 m. c.; overhead cond. DAFT.

Reading, Pa.—Reading & Black Bear Ry.—1½ miles; 2 m. c.; overhead cond SPRAGUE.

Revere, Mass.—Lynn & Boston R. R.—Ocean Ave. line; overhead cond. THOMSON-HOUSTON.

Richmond, Va.—Richmond City Ry. Co.—*Pr.*, J. L. Schoolcraft; *Treas.*, Walter Kidd; *M.*, C. M. Bolton; *Supt.*, Charles Selden; 7½ mi.; g. 4-8½; 30-40 lb.; 50 m. c.; overhead cond. SPRAGUE.

Rochester, N. Y.—Rochester Elect. Ry.—*Pr.*, A. T. Soule; *Sec.*, J. B. Perkins; 9 mi.; 4-8½; 40 lb.; 20 c.; 8 m.

St. Joseph, Mo.—Wyatt Park Ry. Co.—*Pr.*, J. M. Huffman; *Sec.*, I. R. Williams; capital, $300,000; 5 mi.; g. 4-8½; 10 m. c.; overhead cond.; 8 Sprague cars. SPRAGUE.

St. Louis, Mo.—Lindell Ry Co.—*Pr.*, J. H. Lightner; *Supt.*, G. W. Baumhoff; *Eng.*, E. J. Bagnall; —— mi.; g. 4-10; 65 lb.; 1 m. c.; 2 m.; 8 p. c.; storage bats.

Sacramento, Cal.—Sac. Elect. Ry. Co. The Central Street Railway Co.—*Pr.*, L. L. Lewis; *Sec.*, E. K. Alsip; *Tr.*, F. Miller; *Supt.*, J. B. Austin; *Eng.*, ——; 13 mi.; g., 4-8½. Cars to be supplied by Electric Car Co, of America, Philadelphia.

Sault Ste. Marie, Mich.—S. St. M. St. Ry. Co.—*Pr.*, E. M. Lacy; *Sec.*, F. Ryan; *G. M.*, L. G. Cody; 2 mi. FISHER.

Sandusky, O.—Sandusky St. Ry. Co.—*Pr.*, Chas. V. Olds; *Sec.* and *Treas.*, A. C. Moss; *Supt.*, Clark Rude; 4 mi.; g. 4-8½; 32 lb.; 6 m. c.; overhead cond.; 6 Sprague cars. SPRAGUE.

Scranton, Pa.—The People's St. Ry.—*Pr.*, W. Matthews; *Sec.* and *Tr.*, H. E. Hayd; *Supt.*, F. Pearce; 10 mi.; g. 4-8½; 20 m. c.; overhead cond. SPRAGUE.

Seattle, Wash. Ter.—Seattle Electric Ry.—5 mi.; 3 m. c.

South St. Paul, Minn.—So. St. Paul Rapid Transit Co.—*Pr.*, A. E. Clark; *Sec.* and *G. M.*, J. H. Lawrence; (Enos elevated railway); 8 mi. 40 and 56 lb.; 10 m. c.; track conductors. DAFT.

Springfield, Mo.—2 mi. FISHER.

Steubenville, O.—Steubenville Electric Ry. Co.—2¼ mi.; g. 4-8½; 40 lb.; 7% grade: 10 m. c.; overhead cond. SPRAGUE.

Sunbury, Pa.—Sun. & Northumberland St. Ry. Co.—*Pr.*, H. E. Davis; *Sec.*, L. H. Kase; *Tr.*, S. P. Wolverton; 3 mi.; 4 c.; overhead cond.

Syracuse, N. Y.—Third Ward Ry. Co.—*Pr.*, Wm. B. Cogswell; *Sec.* and *Treas.*, W. S. Wales; *G. M.*, H. McGonegal; 4 mi.; g. 4-8½; 8 m. c.; 4 p. c.; steam power; sta. 250 h. p.; overhead cond. THOMSON-HOUSTON.

Tacoma, W. T.—Tacoma St. Ry.—*Pr.*, N. Bennett; 5 mi.; 4 m. c.; overhead. SPRAGUE.

Topeka, Kas.— 14 mi.; 30 m. c.; overhead. THOMSON-HOUSTON.

Worcester, Mass.—Worc. & Shrewsbury—(To be changed from steam to electricity); 2.7 mi.; g. 3; overhead cond. DAFT.

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Notes.

ANSONIA, CONN.—The Derby Horse Railway Co., operating with the Van Depoele electric system, is about to increase its equipment by the addition of considerable Thomson-Houston apparatus.

DES MOINES, IA.—The electrical equipment furnished by the Thomson-Houston company for the Broad Gauge Street Railway Co., is almost ready to be put in operation.

NORTH ADAMS, MASS.—The electrical equipment of the Hoosac Valley Street Railway under the Thomson-Houston system, which it has been intended to defer until next year, will now probably be completed this season.

SYRACUSE, N. Y.—The Third Ward Street Railway Co., (Thomson-Houston system) was to be started about December 1st. The equipment and overhead construction are first-class, and railway men of central New York are looking forward with much interest to see it put in operation.

TOPEKA, KANS.—Work is progressing rapidly for the installation of the Thomson-Houston plant to operate the Rapid Transit Railway. This road when put in operation will be the largest electrical railway in the world, being 14 miles in length.

WICHITA, KANS.—Within the past month the new Thomson-Houston railway has been put in operation here, and is working more successfully than anyone in Wichita believed was possible for an electrical equipment to do, the faith of Wichita citizens in electrical propulsion having been greatly shaken by the failure and removal of a former electrical railway outfit there.

The overhead construction is one of its most striking features, the handsome pole lines affording no cause for objection on the score of disfiguring the streets.

THE SPRAGUE ELECTRIC RAILWAY AND MOTOR CO. has been at work for some time past upon a new design of motor, and several improvements in gearing. The new motor, which will be termed the "Boston," has a new method of winding. The motors are made from 7½ to 15 horse-power. The former method of distributing the weight of the motor and the use of double compression springs is retained. A slight change is made in the method of gearing, and the gears are of vulcanized fibre, thus securing elasticity and noiselessness, and at the same time retaining sufficient strength. The West End Railway, of Boston, is to be equipped with the "Boston" motor as soon as they are manufactured.

A VERY successful demonstration of the possibilities of electric traction for the elevated railroads was given on the evening of November 26, by the the Daft Electric Light Co. The motor car, called the Benjamin Franklin, was attached to three regular passenger cars, containing invited guests to the number of 100, at the 14th street station of the 9th avenue road, and a run was made to 42d street and back. The ordinary speed of the elevated trains was maintained, and the ease with which the train was started and stopped, as well as the entire absence of smoke and smell were commented upon favorably by all present. The trip was made in the midst of a driving rain and under what were considered unfavorable conditions, and the complete success of the trial was, therefore, a source of greater gratification than it would otherwise have been. The motor weighs 10 tons, and it is claimed is as powerful as the 18 ton engines now in use.

Mr. H. M. Hawkesworth, manager of the Daft company, conducted the test. Among those present were noticed: Assistant Manager Campbell, of the Manhattan road, A. H. Van Depoele, E. B. Hyde, Sidney Dillon, H. C. Havemeyer, Robert Lenox Belknap, and Dr. Beckwith.

OMAHA AND COUNCIL BLUFFS.—The electric railway between Omaha and Council Bluffs has been opened for general passenger traffic, and is now running to the satisfaction of its owners and the admiration of the general public.

The road is nine miles in length, and at present is operating 16 motor cars and 16 cars without motors, each motor car towing one of the others. The cars are operated in a manner quite unusual on street railways. They are made by the Pullman Palace Car Co., and are connected by the vestibule device, in use for the first time here on street railway cars; they are very popular, and it is fully believed that this method will ere long come into more general use.

Although the motors work equally well in either direction, a loop is made at each end of the track, to permit the motor car to be always ahead. This road opens a new means of rapid transit between Omaha and Council Bluffs, which is highly appreciated by the residents of the two cities, they having been previously compelled to travel by special trains on the Union Pacific Railroad, which ran once an hour, and upon which 25 cents was charged. The fares upon the new line have been reduced to the usual street railway rates. A speed equivalent to that of the steam road is made over a large portion of the track lying between Council Bluffs and the bridge over the Missouri river.

Great credit is due Mr. T. J. Evans and his associates in carrying through this entire project of rapid transit between the cities, they having expended not less than half a million dollars in constructing a magnificient bridge, 3,000 feet in length, over the Missouri river. No expense has been spared in making the railway one of the finest, if not the best, electric railway in the world.

INVENTORS' RECORD.

Prepared expressly for THE ELECTRICAL ENGINEER, *by* Pope, Edgecomb & Terry, *Solicitors of Patents for Electrical Inventions*, 11 *Wall street, New York city.*

CLASSIFIED LIST OF UNITED STATES ELECTRICAL PATENTS.

From October 23 to November 13, 1888 (inclusive).

Alarms and Signals:—*Electrical Continuity Vibrator*, G. F. Milliken, 391,547, October 23. *Detachable Circuit-Closing Device for Electric Bells and Annunciators*, J. D. Randall, 391,917, October 30. *Police Alarm System*, J. C. Wilson, 392,248. *Magneto-Signaling Apparatus*, M. W. Long, 392,443, November 6. *Combined Fire-Alarm and Telephone Telegraph*, G. C. Hale, A. Barrett and J. Zentner, 392,604. *Auxiliary Fire-Alarm Box*, E. L. Slocum, 392,641. *Signaling Apparatus*, W. Trafford, 392,766. *Individual Signaling Apparatus*, C. N. Talbot, 392,832. *Message and Time Recorder*, J. C. Wilson, 392,888. *Automatic Fire-Extinguisher and Alarm*, I. T. Dyer, 392,951. *Annunciator*, F. Ritchie, 392,970, November 13.

Clocks:—*Clock Synchronizer*, A. G. Wiseman, 391,446, October 23. *Electric Self-Winding Clock*, V. Himmer, 391,969, October 30. *Electric Regulating and Hand-Setting Mechanism for Clocks*, W. S. Scales, 392,230, November 6.

Conductors, Insulators, Supports and Systems:—*Cable Hanger*, E. J. Hall, 391,605. *Conduit for Electric Wires*, M. Dallas, 391,587. *Electric Cable Joint*, J. E. Cuff, 391,517, October 23. *Machine for Making Conduits*, G. Richardson, 392,069. *Electric Conductor*, H. F. Campbell, 392,103. *Insulator for Electric Conductors*, J. C. Love, 392,127, October 30. *Cover for Man-Hole Chambers of Underground Conduits*, M. R. Muckle, Jr., and W. H. B. Teamer, 392,877, November 13.

Distribution:—*System and Apparatus for Electrical Distribution*, M. M. M. Slattery, 391,923. *Electric Distribution by Alternating Currents*, C. Zipernowski, M. Deri and O. T. Blathy, 392,090. *Apparatus for Electrical Distribution*, G. B. Fraley, 392,114, October 30. *Transformation and Distribution of Electric Energy*, W. J. McElroy, 392,213, November 6.

Dynamos and Motors:—*Electric Motor*, J. Doyle, 391,590, October 23. *Electric Motor*, W. E. Hyer, 391,797. *Regulator for Dynamo-Electric Machines*, S. D. Field, 391,954, October 30. *Regulator for Alternating-Current Generators*, R. P. Sellon and W. M. Mordey, 392,370. *Operating Alternate-Current Motors*, W. Stanley, Jr., 392,470. *Alternate-Current Electric Motor*, same, 392,471. *Commutator-Bar for Dynamo-Electric Machines*, C. E. Billings, 392,490, November 6. *Insulation of Cores of Dynamo-Electric Machines*, B. Bidwell 392,660. *Dynamo-Electric Machine*, E. Thomson, 392,765. *Automatic Governor for Dynamos*, E. B. Coburn, 392,855. *Regulation of Electric Motors*, W. Stanley, Jr., 392,890. *Method of Synchronizing Electric Motors*, F. J. Patten, 392,930. *Synchronizing System for Electric Motors*, same, 392,967, November 13.

Galvanic Batteries:—*Galvanic Battery*, H. J. Brewer, 391,505, October 23. *Carbon Battery*, J. B. Wallace, 392,886, November 13.

Ignition;—*Electric Gas Lighter*, J. H. Lehman, 392,440, November 6. *Electric Gas Lighter*, H. A. Cleverly, 392,665. *Electric Machine for Lighting and Extinguishing Gas*, G. E. Thaxter, 392,701, November 13.

Lamps and Appurtenances:—*Electric Arc Lamp*, S. E. Nutting, 391,761. *Incandescent Electric Lamp*, T. A. Edison, 391,596. *System of Electric Lighting*, same, 391,595. *Arc Lamp*, H. W. Libbey, 391,477, October 23. *Manufacture of Incandescent-Lamp Filaments*, J. W. Packard, 391,815. *Flashing Apparatus for Carbon Filaments*, same, 391,816. *Method of Connecting Filaments to Leading-in Wires*, H. Lemp, 392,158. *Apparatus for Mounting Filaments of Incandescent Lamps*, same, 392,159, October 30. *Mast-Arm for Electric Lights*, C. W. Russell, 392,228, *Arc Lamp*, J. C. Young, 392,393. *System of Incandescent Lighting*, C. Heisler, 392,513. *Arc Light Carbon*, J. J. McTighe, 392,520, November 6. *Electric Lamp Switch*, C. G. Perkins, 392,633. *Incandescent Lamp Socket*, T. Coad, 392,666, November 13.

Measurement:—*Electric Measuring Instrument*, A. H. Eddy, 391,592, October 23. *Electrical Measuring Instrument*, V. H. Emerson, 392,018, October 30. *Electro Plated Coil for Electrical Measuring-Instruments*, E. Weston, 392,385. *Electrical Measuring Apparatus*, same, 392,386 and 392,387. *Electric Meter*, P. Lange, 392,437. *Combined Electric Meter and Electric-Clock System*, same, 392,438. *Electric Meter*, same, 392,439. *Reflecting Galvanometer*, E. Weston, 392,476. *Galvanometer*, same, 392,477 and 392,478. *System of Electric Meters*, A. Wurts, 392,577, November 6.

Medical and Surgical:—*Electric Plaster*, H. P. Pratt, 391,720, October 23.

Miscellaneous:—*Arc-Extinguisher for Electric Switches or Cut-Outs*, A. H. Eddy, 391,594. *Automatic Commutator for Alternating Electric Currents*, same, 391,593. *Electric Switch*, W. B. Cleveland, 391,512. *Electric Potential Differentiator*, E. Thomson, 391,437, October 23. *Automatic Electric Heat Regulator*, W. A. Connelly, 391,783. *Method of and Apparatus for Dissipating Electricity in Delivering Sheets from Printing Machines*, W. C. Rossney and C. L. Hunt, 391,820. *Cut-Out for Electric Circuits*, H. C. McDill, 391,853, *Circuit-Closing Mechanism*, C. E. Ongley, 391,855. *Electric Switch or Cut-Out*, W. C. Bryant, 391,943. *Electrical Switch*, O. B. Johnson, 392,034. *Automatic Electric Switch*, I. L. Roberts, 392,167, October 30. *Electric Discharge Device*, R. Belfield, 392,400, November 6. *Electric Speed Governor for Water Wheels*, G. M. Lee, 392,679. *Coin-Controlled Electrical Weighing Scale*, W. R. Smith and A. L. Washburn, 392,698. *Electrical Circuit and Apparatus Guard*, I. H. Farnham, 392,724. *Electrical Apparatus for the Prevention of Incrustation*, M. Kotyra, 392,736. *Electric Circuit*, J. A. Barrett, 392,775, November 13.

Railways and Appliances:—*Railway-Train Indicator*, B. E. Waters, 391,568. *Electric Railway*, P. Wright, 391,447, October 23. *Electric Railway*, I. W. Heysinger, 391,792. *Motor Car for Electric Railways*, same, 391,793, October 30. *Railway Signal*, M. W. Long, 392,444, November 6. *Conduit for Electric Railways*, H. A. Chase, 392,664. *Electric Railway*, R. M. Hunter, 392,675. *Overhead Conductor for Electric Railways*, E. E. Ries, 392,757. *Electrical Railway*, O. Allen, 392,772. *Electric Railway*, B. Herwood, 392,863; I. Robbins, 392,971, November 13.

Storage Batteries:—*Machine for Making Battery Plates*, A. J. Madden, 391,542. *Automatic Circuit Changer for Secondary Batteries*, W. W. Griscom, 391,468, October 23. *Electrode for Storage Batteries*, G. H. Stout, 392,080, October 30. *Secondary Battery*, H. Walter, 392,244. *Method of Making Electrodes for Secondary Batteries*, C. H. Thompson, 392,573. *Electrode for Secondary Batteries*, C. H. Thompson, 392,574, November 6. *Automatic Switch for Secondary Batteries*, J. S. Sellon, 392,826, November 13.

Telegraphs:—*Telegraphy*, S. D. Field, 392,914, November 13.

Telephones, Systems and Apparatus:—*Telephone Exchange System*, C. E. Scribner, 391,762, October 23. *Individual Signaling Apparatus for Telephones*, E. Davis, 391,839. *Telephony*, W. W. Jaques, 392,033, October 30. *Mechanical Telephone*, G. F. Shaver, 392,233. *Telephonic Circuit*, R. M. Bailey, 392,301. *Telephone Switch-Board*, C. C. Gould, 392,326. *Switch-Board for Telephone Exchanges*, F. Blake, 392,403, November 6. *Mechanical Telephone*, L. Mellett, 392,816. *Telephone Support*, S. Bergmann, 392,843, November 13.